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CORRIGENDA.

No. 7, 24 June, 1946.

FLETCHER, H. O. New Lamellibranchia from the Upper Permian of Western Australia. Pages 395–405, Plates xxxiv–xxxv.

The process blocks of the plates of this paper were inadvertently transposed. If Plate xxxiv is regarded as Plate xxxv, and Plate xxxv as Plate xxxiv, these will agree with the explanations and references in the paper.

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THE TAWALLAH VALLEY METEORITE.

General Description.

By T. Hodge-Smith,
The Australian Museum.

The Microstructure.

By A. B. Edwards, Ph.D., D.I.C.,*
Research Officer, Mineragraphy Branch, Council for Scientific and Industrial Research.

(Plates i-ii and Figures 1-2.)

General Description.

Little information is available about the finding of this meteorite. Mr. Heathcock, Constable-in-Charge of the Borroloola Police Station, Northern Territory, informed me in April, 1939, that it had been in the Police Station for eighteen months or more. It was found by Mr. Condon, presumably some time in 1937.

The weight of the iron as received was 75·75 kg. (167 lb.). A small piece had been cut off, but its weight probably did not exceed 200 grammes. The main mass weighing 39·35 kg. (86¾ lb.) is in the collection of the Geological Survey, Department of the Interior, Canberra. A portion weighing 30·16 kg. (66½ lb.) and five pieces together weighing 1·67 kg. are in the collection of the Australian Museum, and a slice weighing 453 grammes is in the Museum of the Geology Department, the University of Melbourne.

The locality is Tawallah Valley, about forty-eight miles north-west of Borroloola, Northern Territory, Australia, latitude 15° 42′ S., longitude 135° 40′ E. approximately.

The shape of the iron is quite unusual in that it is more or less flat and there is an almost complete absence of thumb-marks so characteristic of meteoric iron. The iron contains only a few very small inclusions of troilite and no schreibersite has been found. This does support the view that thumb-marks are due to the decomposition of such minerals during the meteorite's flight through the atmosphere. The flat side forms roughly a parallelogram the longer sides of which are very straight and almost parallel. They are 65 cm. in length and approximately 38 cm. apart. The smaller sides of the parallelogram forming the head and tail of the meteorite are not so straight. The tail particularly is curved toward the centre.

The thickness gradually decreases from the head (65 mm.) to the tail (5 mm.). There is a general tapering from one side to the other, though this difference in thickness disappears toward the tail. One wing of the tail is bent at an angle of about 25° to the plane of the iron. It is possible that this was bent when the iron struck the ground, as there is a fairly large oval indentation on the edge just where the bending takes place, and there is no doubt that this indentation was formed mechanically.

The reverse side is almost perfectly flat with a number of indentations that have been mechanically formed. The larger ones appear to be the result of the iron striking something hard and sharp on reaching the ground. Their formation and orientation confirm the fact that the thick end of the iron was actually the head during flight. The smaller indentations are not oriented and resemble chisel marks and may have been made by man.

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The obverse side is not so flat. There is a mound rising about 25 mm. above the level surface, situated about half-way between the head and the tail and close to the thicker side. There are also four depressions so arranged as to give the appearance of the foot-mark of some beast. There are chisel-like marks similar to those on the reverse side and, like them, probably the result of human activity.

The outer skin is black and very thin. In a number of places it is worn through, showing the bright iron underneath. There is no sign of rippling of the surface similar to that of the Bugaldi (New South Wales) iron. Around the head on the flat side only is a layer of iron less than 1 mm. in thickness, extending not more than 40 mm. from the periphery and ending in a very irregular edge. This may possibly represent the remnant of a wave of molten metal leaving the forward end.

On the corner of the head and on the thinner side are two large oval indentations mechanically formed, probably at the time of contact with the ground.

The first cutting was kindly undertaken by the Chief Mechanical Engineer's Branch of the New South Wales Railways Department. It was cut by a slitting saw in a milling machine. Later, when it was found that the iron was soft and comparatively free from inclusions, a complete section was cut by hand at the Museum. The Railway Department did the polishing. The iron takes a brilliant polish and does not rust easily.

Chemical Analysis.

Fe	Ni	Co	Pt	S	P	C	Total	Sp. Gr.	*n*
82·29	16·90	1·09	Trace	abs.	abs.	0·03	100·31	8·00	4·8

The absence of sulphur would indicate the complete absence of troilite, but this can be true only for the portion analysed, as there are a few scattered inclusions of troilite in a complete section of the iron. The largest of these inclusions does not exceed 2 mm. in diameter. No schreibersite has been detected. The very small amount of carbon is present, in part at least, in a very finely divided state. Of the platinoid metals no iridium was detected and platinum was found to be present to the extent of 0·003 per cent.

The specific gravity is somewhat high. Three separate samples were tested by the ordinary chemical balance method, giving as result 8·002, 8·002, 8·001. Another piece tested by the Chemical Branch of the Department of Mines gave a result of 7·997. The average of these readings is 8·00.

This is the highest value that I have been able to find for any meteorite except for the Botetourt iron (O. Sjostrom, 1898), of which the specific gravity is recorded as 8·186.

The theoretical specific gravity for an iron-nickel of the composition of the Tawallah Valley, using the specific gravities given in the Smithsonian Physical Tables (1920), is for the minimum value 7·903 and for the maximum 8·001.

On etching a polished surface with dilute nitric acid a distinct etch pattern was produced showing in its orientation a resemblance to the usual Widmanstätten figures. The usual bands of kamacite and taenite were replaced by a definite sheen. A similar etch pattern has been recorded for many of the nickel-rich irons. No satisfactory explanation of this structure has been offered. Dr. Edwards very kindly offered to undertake a mineragraphic examination with a view to supplying this explanation. That he has been entirely successful will be realized from his notes published below.

According to the analysis, this iron belongs to the nickel-rich ataxites, Group 3 of Prior's Classification. Spencer records twenty-three nickel-rich ataxites. Since that time the Tschinga iron (Ni 16·71 per cent; *n* 5) has been recorded, so that this iron makes the twenty-fifth record and the first for Australia. The Arltunga (Central Australia), with a value for *n* of 8·6, is just on the border-line between the finest octahedrites and the nickel-rich ataxites. It is reported as having a micro-octahedral structure. The Yarroweyah (Victoria) is the only Australian nickel-poor ataxite.

In view of the apparently constant structure to be found in nickel-rich iron and the fact, as shown by Dr. Edwards for the first time, that this structure is closely related

to the octahedral structure, the name ataxite, meaning without order, is no longer applicable. The term ataxite should be confined to those irons in which the nickel content is too low to produce a definite structure of the nickel-iron alloys. It is suggested that the term eotaxite should be applied to those irons rich in nickel in which the early stage of the formation of the Widmanstätten structure is developed.

The Microstructure.

Examination of the polished sections of the Tawallah Valley iron in reflected light reveals that it consists almost wholly of nickel-iron with an occasional bleb of iron sulphide, from 1 to 2 mm. in diameter.

Iron Sulphides.

The blebs of iron sulphide vary somewhat in composition. Some consist of troilite, others of pyrrhotite. The distinction between them is that troilite, which contains more sulphur, effervesces with dilute nitric acid, and gives off hydrogen sulphide, which stains the iron, while the pyrrhotite is practically inert to dilute nitric acid. One bleb of pyrrhotite examined consisted of several allotriomorphic crystals, some of which showed lamellar twinning. The pyrrhotite is creamy-brown in colour, strongly anisotropic, and shows reflection pleochroism. The powder is magnetic. Of the standard etching reagents, potassium hydroxide slowly stains the pyrrhotite brown, while the other reagents are negative. When a portion of the meteorite was dissolved in dilute nitric acid, a complete, but somewhat etched, prismatic crystal of pyrrhotite, about 2 mm. × 0·5 mm., was set free. The crystal was elongated in the prism direction, and showed the forms $(10\bar{1}1)$, $(10\bar{1}0)$, (0001). Measurements under a microscope gave $(0001) \wedge (10\bar{1}1) = 45° \pm 30'$; $(10\bar{1}0) \wedge (10\bar{1}1) = 45° \pm 30'$.

Nickel-Iron.

When polished sections are etched with a 2 per cent. solution of nitric acid in alcohol for a few seconds (or with bromine water, or 2 per cent. picric acid in alcohol), a microstructure such as is shown in Plate ii, Fig. 1, develops. This structure is composed of two components, and is more or less comparable with the martensite-like structure shown by artificial Fe-Ni alloys with 10 to 25 per cent. Ni that have been annealed from 1300°C. (Marsh, 1938, p. 47). The more readily etchable constituent forms lamellae and more or less diamond-shaped or lens-like bodies in the other constituent, which acts as host. These large bodies are oriented in definite directions, presumably related to the crystallographic directions of the host. Study of Figures 3 and 6 shows that there are three such directions. Two of them are well marked, while the third is only weakly developed, but can be detected in the diamond-like shape of many of the bodies.

In the regions between these large oriented bodies there is developed what appears to be a similar intergrowth, but on a much finer scale. At the margins of the large bodies, however, the host constituent has been drained clear, presumably by diffusion during the growth of the large bodies. The structure is typically that of an ex-solution, and since the materials consist solely of iron and nickel (plus cobalt), it must represent a stage in the transformation of γ-nickel-iron to α-nickel-iron. The ex-solution bodies are presumed to consist of α-nickel-iron, oriented parallel to the octahedral directions of the original γ-nickel-iron crystals.

This oriented microstructure gives rise to a "schiller" on the surface of polished and etched specimens, when the specimen is observed in oblique light (Plate ii, fig. 5). There is a narrow band around the edge of the meteorite (Plate ii, fig. 5), much thicker on one side than on the other, in which the microstructure is lacking. This band consists of γ-nickel-iron, and the absence of ex-solution bodies of α-nickel-iron from it must be attributed to its rapid chilling.

A third constituent of the nickel-iron is also revealed by etching with 2 per cent. nitric acid in alcohol, or other etching reagents. As shown in Plate ii, fig. 2, it consists of small irregular, often elongated or rounded, grains of a substance which is not

attacked by the etching reagents, even with prolonged etching. These grains are almost invariably associated with the ex-solution bodies of α-nickel-iron. They were formed prior to the ex-solution, because the bodies of α-nickel-iron are commonly moulded on them, or even enclose them (Plate ii, fig. 4). Apparently the grains of this third constituent served as nuclei about which the ex-solution bodies grew. Careful examination of the unetched polished specimens in reflected light reveals that under high magnification these grains can be distinguished from the main nickel-iron intergrowth by the fact that they show a slight brownish tint. When such polished sections are left exposed, a tarnish film develops on the ($\alpha + \gamma$) nickel-iron intergrowth, but the grains of the third constituent remain bright (Plate ii, fig. 2).

The chemical composition of the meteorite indicates that this mineral is also an alloy of nickel and iron; and in view of its resistance to acid etching reagents, it is presumed to be one which is rich in nickel. By way of confirmation a piece of the iron weighing about 20 grams was dissolved in 2 per cent. nitric acid, solution being complete at the end of four weeks. A crystal of pyrrhotite, and a small amount of black insoluble powder were left. The powder, when filtered and dried, weighed only 0·005 gram. This was too little for a quantitative analysis with the means available, so qualitative microchemical tests were carried out on it. Strong positive tests were obtained for iron and nickel, and the tests indicated that the iron was the more copious of the two. Tests for cobalt were doubtfully positive. Tests for phosphorus were negative. The mineral is regarded, therefore, as being an iron-nickel alloy in the γ-phase, and containing about 25–30 per cent. of nickel, i.e. *taenite*.

Standard etching reagents affect the iron as follows. Nitric acid (1:1) etches the α-iron, roughening its surface, and slowly attacks the Ni-poor γ-iron surrounding it. The Ni-rich γ-iron grains are not affected. The areas of fine ($\alpha + \gamma$) intergrowth between the large α-lamellae are blackened instantaneously. This suggests that the blackened areas commonly found associated with taenite (Ni-rich γ-iron) on etching are finely microcrystalline intergrowths of α- and γ-iron, as claimed by Smith and Young (1939), and are not due to the presence of either phosphide or carbon in solid solution in the iron, as has been suggested by other writers (Johnston and Ellsworth, 1921; Vanick, 1925). Hydrochloric acid (1:1) is negative, but the fumes tarnish the surface lightly, and reveal the microstructure of the iron. The iron washes clean. Potassium cyanide and potassium hydroxide are negative; but ferric chloride and mercuric chloride both etch the iron instantaneously. The ferric chloride blackens the α-iron, but leaves all the γ-iron untouched. The orientation of the minute bodies of α-iron in the "groundmass" between the coarser α-iron ex-solution bodies is particularly well brought out by this etching (Fig. 6). Mercuric chloride blackens the surface immediately, and rubs to an etched surface. The α-iron is attacked, but the γ-iron is unaffected. The grains of Ni-rich γ-iron (taenite) stand out sharply in the etched section.

Origin of the Microstructure.

The microstructure of the Tawallah Valley iron is readily explained by reference to the generally accepted iron-nickel equilibrium (as shown by Marsh, 1938, p. 55; Hanson, 1936), which is reproduced diagrammatically in Fig. 1. The exact location of the high temperature points connected with the peritectic region and the boundaries of the ($\alpha + \gamma$) field are uncertain, but the general features of the diagram are firmly established.

Consider the cooling history of an iron-nickel alloy containing about 18 per cent. of nickel, which is the composition of the Tawallah Valley iron, if Co is regarded as Ni. Solidification of the melt would commence at about 1480°C., with the separation of γ-iron containing 11 to 12 per cent. of nickel, leaving the residual liquid enriched in nickel. If cooling was sufficiently slow to permit the establishment of equilibrium, solid diffusion would keep pace with crystallization, and upon complete solidification the iron would contain 18 per cent. Ni, while the final drop of liquid to crystallize would contain about 25 per cent. Ni. If, however, cooling was too rapid for equilibrium

to be established, the composition of the γ-iron formed would range from 11 per cent. Ni up to 25 per cent. Ni, or even higher, and the Ni-rich crystals, being the last to form, would tend to be small and would form in the interstices and grain boundaries of the earlier-formed Ni-poor γ-iron. As pointed out by March (1938, p. 35), the Ni-atom is very similar to the Fe-atom, so that the probable rate of diffusion of Ni in Fe is very slow. As a result, these differences in Ni-content in different crystals of the alloy would tend to persist during subsequent cooling.

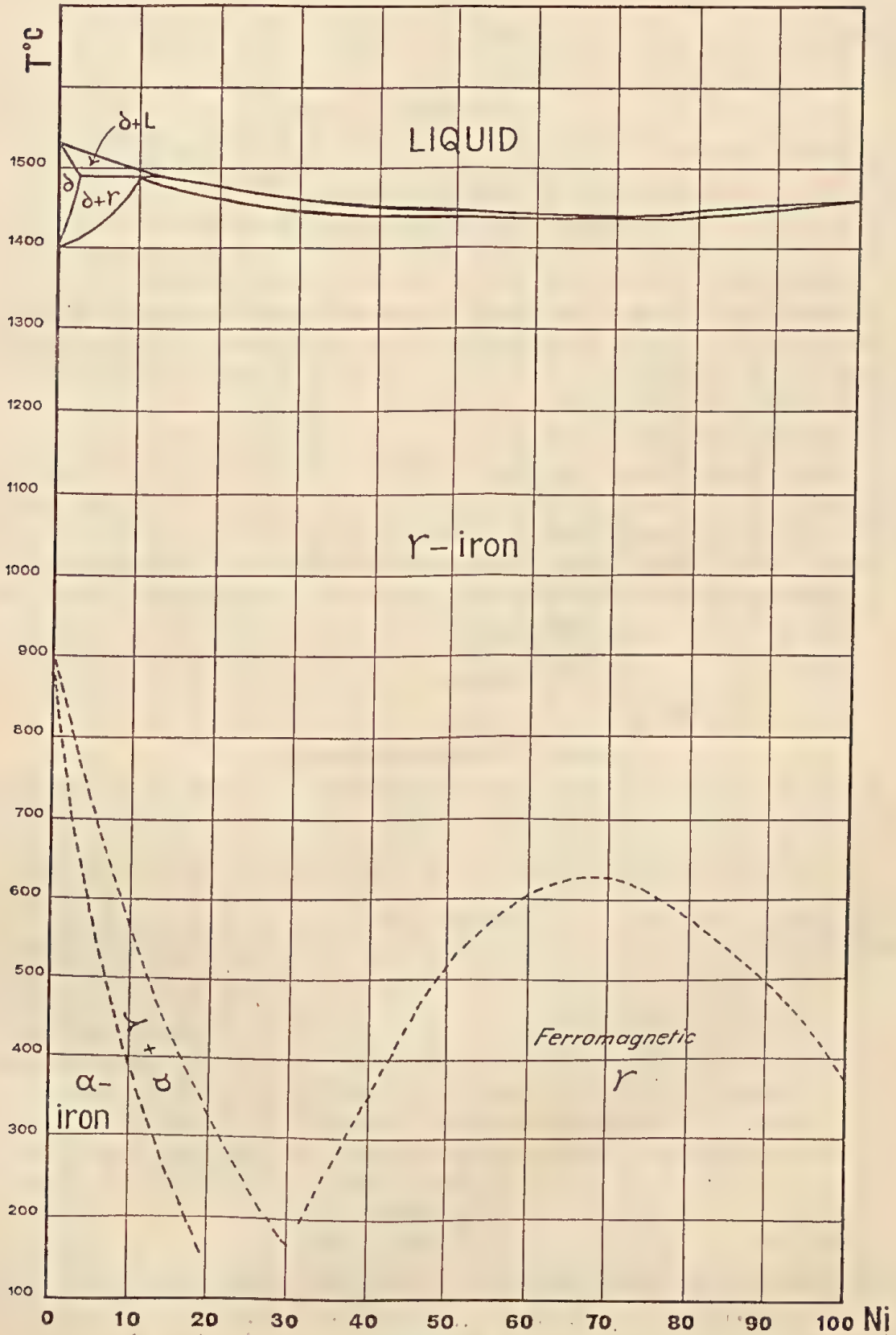

Fig. 1.—The iron-nickel equilibrium diagram, after Marsh (1938).

In an iron-nickel alloy of the composition of the Tawallah Valley meteorite it might well happen that equilibrium would be maintained during the early stages of solidification in view of the more rapid rate of diffusion of Ni in the Ni-poor γ-iron, and fail during the later stages of solidification, when a high Ni concentration had developed in the isolated droplets of residual melt. In this way the mass of the γ-iron would have a relatively uniform composition, about 15 to 17 per cent. of Ni, and only the minute, last-formed, interstitial crystals would consist of Ni-rich γ-iron.

On the further cooling of such an alloy, the γ-iron enters the (α + γ) field, and begins to transform to α-iron. This transformation is accompanied by an enrichment in nickel of the remaining γ-phase. As will be seen from Fig. 1, addition of Ni to the γ-iron causes a decrease of the temperature, at which the γ to α transformation begins, to so low a degree that the resistance to transformation finally becomes very great, and transformation more or less ceases as the Ni-content approaches 25 per cent. Meteoric irons with no more than 10 per cent. Ni would readily convert from the γ to the α phase, and only a small quantity of γ-iron with as much as 25 per cent. Ni (taenite) will remain. Moreover, the α-iron so formed will contain not more than 6 per cent. Ni (i.e. will be kamacite). Where, however, the original γ-iron contains about 15 to 18 per cent. Ni, as in the case of the Tawallah Valley iron, it will enter the (α + γ) field at so low a temperature that only a partial transformation can take place, and the final product of cooling will be an intergrowth of ex-solution bodies of α-iron in a matrix of γ-iron. Moreover, such crystals of Ni-rich γ-iron as formed the final products of solidification will not undergo any transformation to the α-phase, but will remain as isolated blebs in the (α + γ) matrix.

Normally, the addition of Ni to the residual γ-phase iron during the γ to α transformation would yield a residue of γ-iron almost as rich in Ni as these blebs; but in a case such as we are considering, the inability of the transformation to proceed beyond a preliminary stage, owing to the arrest of the process by further cooling, will prevent more than a small amount of Ni being transferred to the residual γ-iron, so that it will fail to approach a composition comparable with the Ni-rich γ-iron blebs. As a result, there will occur γ-iron of two compositions, one considerably richer in Ni than the other; and the difference in Ni-content may be sufficient to produce a slight difference in colour and in etching properties, such as is found in the constituents of the Tawallah Valley iron.

Origin of Widmanstätten Structure.

The ex-solution structure found in the Tawallah Valley iron throws additional light on the origin of Widmanstätten structure. The early formed ex-solution bodies of α-iron segregate in the octahedral crystallographic directions of the γ-iron crystals; and as they grow they develop into laminae elongated in these directions. Thus there developed three sets of parallel lamellae, inclined to one another at 60°. The actual angles seen in sections will, of course, vary with the direction in which the section is cut. As more and more molecules of α-iron are drained from the transforming γ-iron, the residual γ-iron, which is being enriched in Ni, becomes isolated between the widening lamellae of α-iron. Finally, when the Ni-content of this residual γ-iron has been raised to about 25 per cent. Ni, further transformation to α-iron becomes impossible, and the mass of iron becomes stable as an intergrowth of lamellae of α-iron (kamacite) of widths varying according to the Ni-content of the original melt, separated by bands or lamellae of Ni-rich γ-iron. Each α-iron lamella is oriented in one or other of the three octahedral crystallographic directions of the original γ-iron crystals, and the residual taenite lamellae have, perforce, a similar orientation. This combination of oriented, interleaved, lamellae of Ni-poor α-iron (kamacite) and Ni-rich γ-iron (taenite) gives rise on etching to the well-known Widmanstätten structure.

When, as in the Tawallah Valley iron, this process of ex-solution is arrested at an early stage, etching of a polished section gives rise to an octahedral "schiller", showing the same orientation as Widmanstätten structure, and being, in fact, an incipient development of that structure. The Tawallah Valley iron presents, therefore, a con-

firmation of the explanation of Widmanstätten structure advanced by Derge and Kommell (1937).

The Microstructure of Ni-rich Ataxites.

If the above explanation of the microstructure of the Tawallah Valley iron is correct, then it follows that all iron meteorites with a Ni-content between 15 and 20 per cent. Ni should possess similar microstructures; and from what information is available this would seem to be likely, although few such meteorites have been subjected to mineragraphic investigation.

Thus the Hoba meteorite (Spencer, 1932), which contains about 17 per cent. Ni (plus cobalt), consists of an extremely fine ($\alpha + \gamma$) intergrowth (described by Spencer as "plessite"), similar to the finer intergrowth structure in the areas between the coarse ex-solution bodies of α-iron in the Tawallah Valley iron. The constituents of this intergrowth show a well-marked orientation, which on etching gives rise to a "sheen" on the etched surface, when it is viewed in oblique lighting. Scattered through this intergrowth are numerous grains of a white mineral not etched by dilute nitric acid. Spencer has suggested that these are grains of (?) schreibersite, or possibly cohenite. They are not likely to be cohenite, because there is only 0·02 per cent. of carbon in the meteorite, and so small an amount would be retained in solid solution in the γ-iron of the intergrowth. Schreibersite, on the other hand, is known to be harder than nickel-iron (Johnston and Ellsworth, 1921), whereas the mineral in the Hoba iron is reported to be softer than the nickel-iron. This, as will be seen from the discussion of the Brinell hardness tests on the Tawallah Valley iron, which follows, agrees with the hardness of taenite; and the probability is that these small grains, which so resemble the taenite grains in the Tawallah Valley iron, will prove to be taenite also.

The so-called "sheen" or "schiller" that is observed on etched surfaces of the Hoba and Tawallah Valley irons, when lit by oblique light, is a macroscopic effect of this particular microstructure; and the fact that other Ni-rich ataxites show such an effect is evidence that they possess a comparable microstructure.

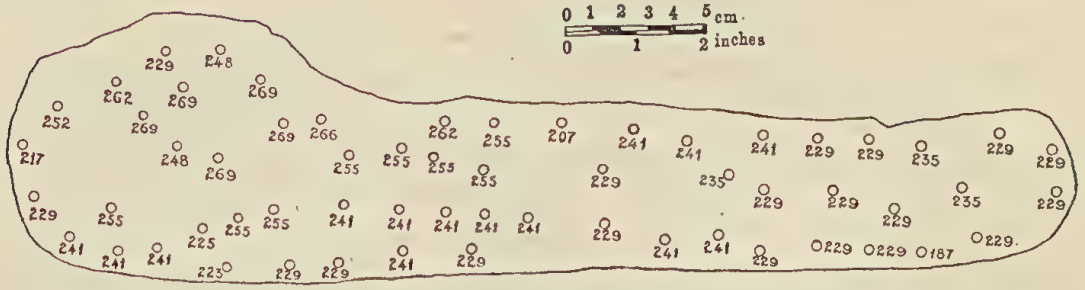

Fig. 2.—Brinell Hardness Survey on section of the Tawallah Valley iron.

Brinell Hardness.

A study of the Brinell hardness (Fig. 2) of the iron was made by Mr. R. A. Holloway, Testing Engineer, Department of the New South Wales Railways, who supplied the following note:

"The hardness survey carried out over a cross-section of the meteorite reveals a remarkable uniformity. Apart from the two low readings of 187 and 207, which are probably due to sponginess at these isolated points, the narrower end of the section shows a hardness range of 229 to 255. If the usual conversion factor of 0·22 is used, this represents a tensile strength range of from 50·4 to 56·1 tons per square inch.

"The thicker end shows a tendency towards higher hardnesses (up to 269) which may be due to some segregation in the centre of the section where it might reasonably be expected to occur.

"The homogeneous nature of the meteorite is also revealed by the shape of the Brinell impressions, which are quite circular and show no sign of irregularity such as is found in heterogeneous bodies."

Polished sections were prepared of pieces showing hardnesses of 229, 235 and 241, but they showed no apparent differences in structure or composition when examined under the microscope in reflected light.

In view of the fact that the hardness of annealed iron-nickel alloys ranging in composition between 6 and 25 per cent. Ni shows a marked change with a small change of Ni-content (ranging from 150 at 6 per cent. Ni, to 225 at 9 per cent. Ni, with a maximum of 290 at 17 per cent. Ni, and then falling to 250 at 24 per cent. Ni, and 150 at 26 per cent. Ni) (Marsh, 1938), it seems probable that these slight variations in hardness in the Tawallah Valley iron are due to slight local variations in the Ni-content of the iron, arising from a failure to establish complete equilibrium during solidification. While the hardness behaviour of annealed alloys is not necessarily comparable with those of a meteoric iron, it may be recalled that the annealed artificial alloys of this range of composition develop martensite-like microstructures more or less similar to those shown by the Tawallah Valley iron.

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EXPLANATION OF PLATES.

Plate I.

Fig. 1.—View looking at the thinner side of the Tawallah Valley iron, showing one tip of the tail bent, and an oval indentation mechanically formed on the edge close to the head. Photograph by G. C. Clutton.

Fig. 2.—The obverse side of the Tawallah Valley iron. Photograph by G. C. Clutton.

Fig. 3.—View looking at the head of the Tawallah Valley iron. Photograph by G. C. Clutton.

Plate II.

Fig. 1.—Typical ex-solution structure of the Tawallah Valley iron, showing coarse ex-solution bodies of α-iron growing in the crystallographic directions of the γ-iron. In the areas between these bodies is a host of minute ex-solution bodies of α-iron. The α-iron adjacent to the large bodies has been drained free of these minute bodies. Etched with 2 per cent. nitric acid in alcohol. × 150. Photograph by A.B.E.

Fig. 2.—The same as Figure 3, but magnified, showing a large ex-solution body of α-iron, enclosing a grain of nickel-rich iron (taenite), and surrounded by γ-iron of lower nickel content. × 600. Photograph by A.B.E.

Fig. 3.—Grains of nickel-rich γ-iron (taenite) set in the $(\alpha + \gamma)$ matrix. Tarnished by exposure, leaving the taenite grains white. × 500. Photograph by A.B.E.

Fig. 4.—Section of the Tawallah Valley iron etched with $FeCl_3$ solution showing the orientation of the finer-grained ex-solution bodies of α-iron parallel with the coarser α-iron bodies. × 150. Photograph by A.B.E.

Fig. 5.—A plate of the Tawallah Valley iron, which has been polished and etched, so that it shows a "schiller" pattern when photographed in oblique light. Natural size. Photograph by J. S. Mann.

SOME PARASITIC NEMATODES IN THE COLLECTION OF THE AUSTRALIAN MUSEUM.

By T. Harvey Johnston and Patricia M. Mawson,
University of Adelaide.

(Figures 1–26.)

A small collection of unnamed parasitic nematodes belonging to the Australian Museum was submitted to us for examination. Those from marsupials have already been dealt with (Johnston and Mawson, 1940), the remainder, from reptiles, birds and rodents, are recorded in this paper. The greater part of the collection was made by Mr. E. Troughton while visiting South Australia on a collecting trip on behalf of the Museum. Two other members of the staff, Messrs. F. A. McNeill and H. S. Grant, also contributed to it. Some material belonging to the old collections of the Museum and obtained by G. Masters and G. Krefft was also examined, but its condition was rather unsatisfactory. The host names, locality, parasites identified, and Museum registered number, are as follows:

Reptiles.

Varanus varius Shaw, from Birchmore Lagoon, Kangaroo Island: *Physaloptera antarctica* var. *typica* Irwin-Smith (W1061).

Elseya dentata Gray, Queensland: *Spironoura elseyae* n. sp. (G11106).

Birds.

Malurus leuconotus Gould, Mt. Lyndhurst, South Australia: Two cysts of *Filaria* (s.l.) sp. (W1077).

Cysticola exilis Vig. and Horsf., Moa (Banks) Island, Torres Strait: *Diplotriaena tricuspis* Fedtsch. (W989).

Chibia bracteata Gould, Russell Island, Queensland: *Hamatospiculum chibiae* n. sp. (W1611).

Ninox boobook, Hayman Island, Whitsunday Group, Queensland: *Hamatospiculum mcneilli* n. sp. (W.3147).

Nycticorax caledonicus Gmelin, Bulli district, N.S.W.: *Contracaecum nycticoracis* n. sp. (W3236).

Polyteles alexandriae Gould, Beecroft, N.S.W. (in captivity): *Ascaridia columbae* (Gmelin) (W3238).

Strepera fuliginosa Gould, Deep Creek, Kangaroo Island: *Oxyspirura streperae* n. sp (W1075).

Halcyon pyrrhopygius Gould, Mt. Lyndhurst, South Australia: *Hamatospiculum halcyonis* n. sp. (W1074, W1070, and W1063).

Halcyon sanctus Vig. and Horsf., Kingscote, Kangaroo Island: *Hamatospiculum halcyonis* n. sp. (W1076).

Corvus, probably *cecilae* Matthews, Mt. Lyndhurst, South Australia: *Acuaria corvicola* n. sp. (W1057).

Mammals.

Melomys banfieldi De Vis, Dunk Island, Queensland: *Physaloptera banfieldi* n. sp. (W3237).

Rattus assimilis Gould, Deep Creek, Kangaroo Island (W1060); Birchmore Lagoon, Kangaroo Island (W1055); *Physaloptera troughtoni* n. sp.

Mus musculus Linn., Moree, New South Wales: *Protospirura muris* (Gmelin) (G10983).

"Rats", probably *Rattus rattus* var., Lismore, New South Wales: *Protospirura muris* (Gmelin) (W893).

"Brush-tailed Rat"—almost certainly the polyprotodont marsupial *Phascogale penicillata* (Shaw)—Locality not stated, but probably the Sydney district: *Denticulospirura dentata* n.g., n. sp. (G11109).

Denticulospirura dentata n.g., n. sp.

(Fig. 1.)

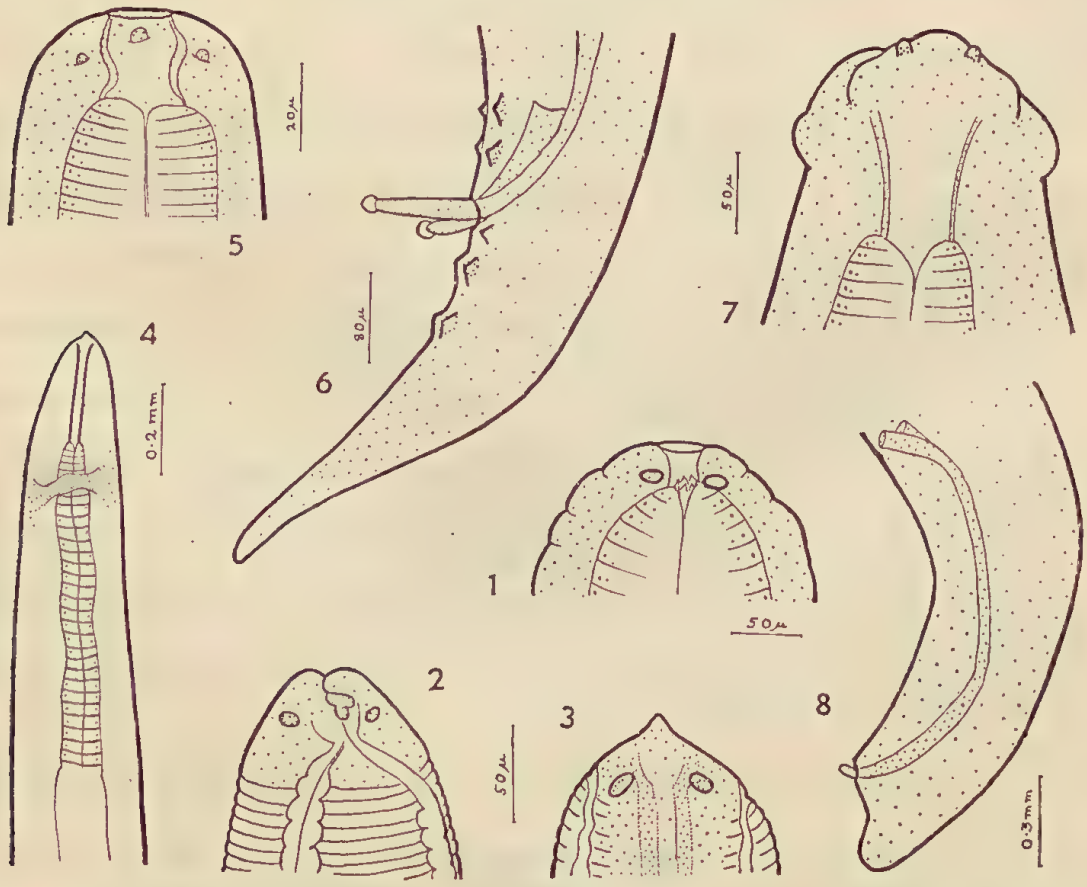
From a "Brush-tailed rat", probably a marsupial, *Phascogale penicillata*; G11109. Single immature female present 52 mm. long, ·88 mm. wide. Anterior end more or less rounded; no lips; four submedian oral papillae. Mouth leading to cylindrical vestibule 20μ long, with six triangular teeth at its base. Oesophagus straight, ·24 mm. wide, surrounded by nerve ring ·36 mm. from head. Excretory pore ·48 mm. from head, associated with sac-like "gland" or "bladder"; latter ·48 mm. long, lying parallel with oesophagus posteriorly from excretory pore. Tail ·1 mm. long, rounded except for terminal spine 9μ long; body width at level of anus ·11 mm.

The characters of the head do not appear to agree with those of any Spiruroid genus yet described. The head characters are so distinctive that, although our specimen is but a young female, we consider it necessary to erect for it a new genus, *Denticulospirura*, whose characters are as follows: Spirurinae: anterior end rounded, posterior tapering; no lips; four submedian oral papillae. Mouth leading into circular vestibule with six teeth at its base; oesophagus straight. Male unknown. Female with tail ending in short spike; position of vulva unknown. Type *D. dentata* n. sp.

Acuaria corvicola n. sp.

(Figs. 2–4.)

A single female worm (Reg. No. W1057) found in the stomach of a crow, probably *Corvus cecilae*, from Mt. Lyndhurst, South Australia. Collected by Mr. E. Troughton.



Figs. 1-8.—1. *Denticulospirura dentata*; 1. head. 2-4. *Acuaria corvicola*; 2. head, ventral view; 3. head, lateral view; 4. anterior end. 5-6. *Oxyspirura streperae*; 5. head of female; 6. male tail. 7-8. *Spironoura elseyae*; 7. head; 8. male tail. Figs. 2 and 3 to same scale.

It is 19·6 mm. long, ·36 mm. wide. Body transversely striated except at the four cordons. Each of the two lateral lips with two large papillae. Cordons nearly reaching mid-body. vestibule ·23 mm. long; oesophagus ·75 mm. long, nerve ring surrounding it at ·35 mm. from head. Tail tapering, rounded extremity, ·3 mm. long. Vulva just posterior to middle of body, 9·9 mm. from head; vagina extending posteriorly. Eggs about 20μ by 30μ, with embryos.

Oxyspirura streperae n. sp.
(Figs. 5–6.)

Collected by Mr. E. Troughton from under the eyelids of *Strepera fuliginosa* at Deep Creek, Kangaroo Island (Reg. No. W1075). Males about 12–13 mm. long, ·22 mm. wide; females 15–18 mm. long, ·31 mm. wide. Body of uniform width, tapering near both ends, anterior end rounded; tail long, pointed. Circular mouth surrounded by one pair of lateral and two pairs of sub-median papillae; strongly chitinized buccal cavity wider in its mid-length than at either end, 35μ long, 28μ wide at middle. In young females oesophagus narrower anteriorly to excretory pore. Oesophagus in adult without division into anterior and posterior parts; 1·3 mm. long in a female 16·4 mm. long, ratio about 1:13 of body length. Nerve ring ·15 mm. and excretory pore ·28 mm. from head end.

Male: caudal papillae large, prominent, three pairs preanal, three pairs postanal, the most anterior pair of postanals being more laterally situated. Longer spicule, ·4 mm., cylindrical proximally, flattened distally, with narrow alae towards its tip in distal third; shorter spicule coarse, blunt, ·16 mm. long; points of both with membranous tips. Tail ·35 mm. long.

Female: anus ·4 mm., and vulva 1 mm., from tip of tail. Eggs 40μ by 20–24μ, thick-shelled, embryonated.

This species does not agree with *O. mansoni* (Cobbold), in the shape and size of spicules and in the shape of the buccal capsule. *O. acanthochaerae* Johnston 1912 is shorter, has the nerve ring differently situated, and a different arrangement of the vulva and anus. *O. sigmoidea* (Molin) is shorter and wider, and has a coiled tail and differently arranged caudal papillae in the male.

Physaloptera banfieldi n. sp.
(Figs. 9–10.)

From *Melomys banfieldi*, collected by the late E. J. Banfield at Dunk Island, north Queensland (Reg. No. W3237).

Very short worms; male 10–12 mm. long, 1 mm. wide; females 15–20 mm. long, 1·5 mm. wide. Cephalic collarette not deeply reflected over lips. Each lip with two median teeth of approximately equal height, inner tripartite; no other teeth present. Oesophagus 2·8 mm. long in male, 3·5–4 mm. in female (a fifth to a quarter of body length), anterior muscular part ·4 mm. long in male, ·4–·5 mm. in female (a seventh and an eighth oesophageal length respectively). Nerve ring around posterior end of muscular part of oesophagus; cervical papillae small, hook-like, about ·45 mm., behind nerve ring in young female.

Male: alae wide, voluminous, not joined posteriorly; cloaca ·55 mm. from tip of tail. Spicules ·55 and ·42 mm. long. Six pairs of pedunculate papillae in groups laterally from cloaca; three sessile papillae immediately in front of cloaca; four immediately posterior to it; and two pairs on the ventral surface of tail, the second of them being midway along tail.

Female: vulva in oesophageal region; in a worm 15 mm. in length, with oesophagus 3·48 mm. long, vulva is 2·7 mm. from head, vagina 1·1 mm. long, egg chamber ·6 mm.; in worm 20 mm. in length, vagina ·6 mm. long, egg chamber ·9 mm. These dimensions support Miss Irwin-Smith (1922) in her suggestion that the actual measurements of different parts of the female genital tract in *Physaloptera* are of no diagnostic value; and, besides, the relative sizes of egg chamber and vagina vary with the number of eggs in the former. Two uteri; receptacula seminis short, broadly pyriform. Eggs 25μ by 41μ. The species is named in acknowledgement of the work of the late Mr. Banfield, who was

the author of interesting books on the natural history of Dunk Island, where he spent so many years of his life.

Physaloptera troughtoni n. sp.
(Figs. 11–13.)

From the stomach of *Rattus assimilis*, collected by Mr. E. Troughton at Birchmore Lagoon and Deep Creek, Kangaroo Island (Reg. No. W1055, W1060).

Long slender worms, males to 26 mm. long, females to 42 mm. Cephalic collarette not covering lips; each lip with two median teeth, the inner tripartite and shorter; no other teeth present. Four large sub-median papillae on lips. Oesophagus about 4·2–4·3 mm. long in both sexes; with anterior muscular part ·52 mm. and ·6 mm. long in male and female respectively; surrounded near base (·52 mm.–·56 mm. from lips) by nerve ring. Cervical papillae 1 mm. from head.

Male: bursa 2 mm. long; cloaca at about mid-length of bursa, ·9 mm. from tip. Four pair of pedunculated papillae laterally about level of cloaca; three sessile preanal and four sessile postanal papillae; behind these three pairs on ventral surface of tail, third pair about midway between tip and cloaca; central one of the three preanal papillae sometimes double. Spicules equal, tapering, ·36 mm. long. Ventral surface of tail bearing tubercles distributed as shown in Fig. 12.

Female: maximum width ·8 mm. Tail ·35 mm. long, conical. Two uteri uniting to form short common duct, leading to fusiform egg chamber and short vagina, opening just posterior to oesophagus. Eggs in vagina 40–43μ by 25–26μ.

This species closely resembles *P. muris-braziliensis* Diesing, differing from it in the position of the vulva, and in the shape of the bursa, whose more elongate form, the absence of a median ventral papilla and the more anterior situation of the three ventral pairs of papillae are distinguishing features of *P. troughtoni*.

Physaloptera antarctica Linstow var. typica Irwin-Smith.

From the intestine of *Varanus varius* caught near the Birchmore Lagoon, Kangaroo Island, by Mr. E. Troughton (Reg. No. W1061).

The worms agree very closely with the description given by Irwin-Smith (1922, 233). The row of denticles on each lip on either side of the median tooth consists in our specimens of more than the three teeth described by this author, and there appears to be a wider range in the branching of the four uteri from the common duct, in some cases the four diverging at the same level, others showing a strictly dichotomous arrangement as indicated in her figures. One specimen showed three uteri coming from the common duct, one of these bifurcating after a short distance. We assigned the worms to the variety *typica* because of their slender build.

Protospirura muris (Gmelin 1790).

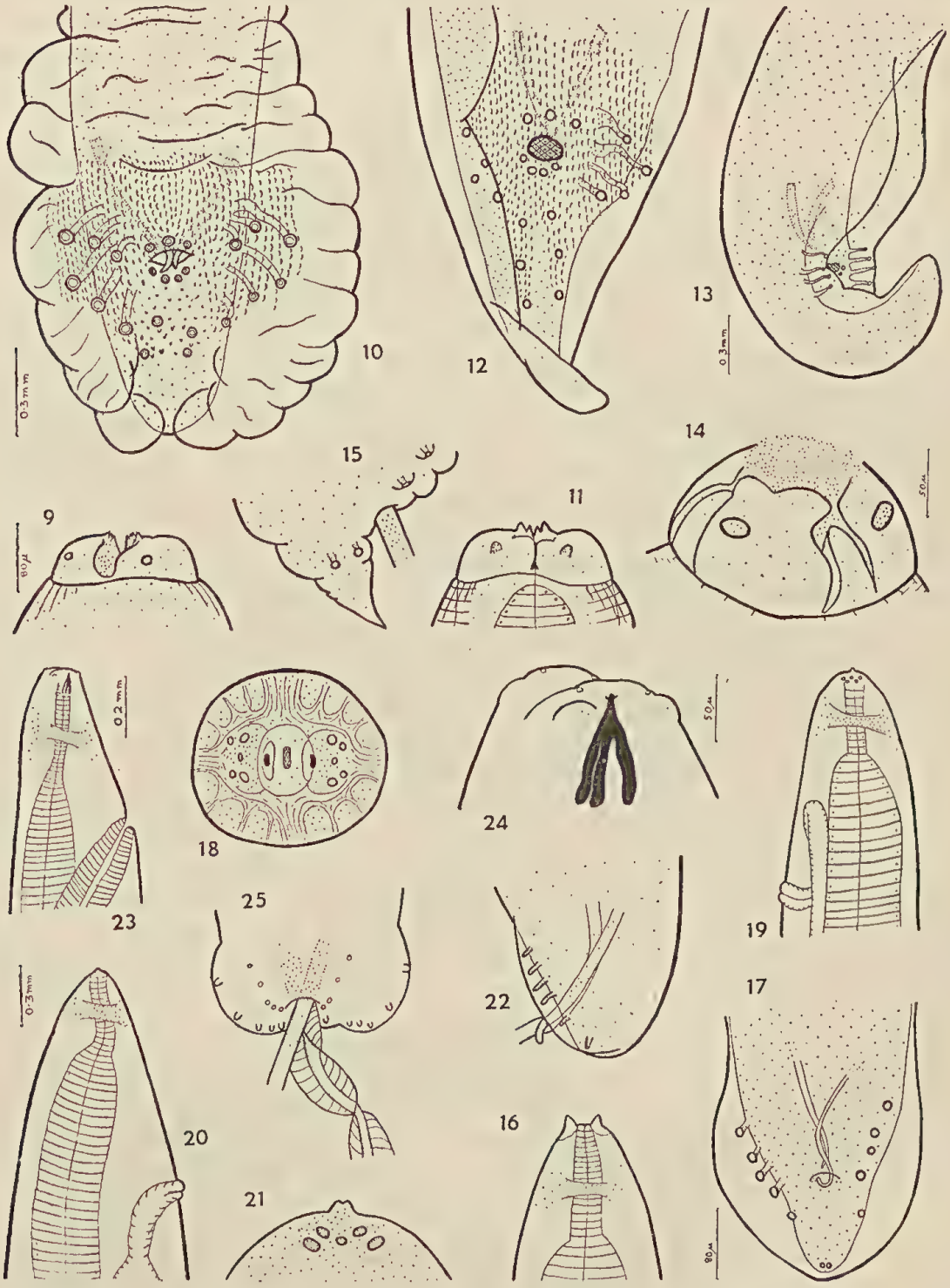
We have assigned to this species some female worms from a house mouse (*Mus musculus*) from Moree, New South Wales (Reg. No. G10983), and a collection of males and females from rats from Lismore, New South Wales (Reg. No. W893). We did not observe on the male tail a median preanal papilla nor a group of eight tiny papillae subterminally, which are apparently present in typical *P. muris*. This difference, however, was not considered sufficient to justify the erection of a new species.

Hamatospiculum mcneilli n. sp.
(Figs. 16–17.)

Collected by Mr. F. A. McNeill from the tissues adjacent to the skull of *Ninox boobook* at Hayman Island, Whitsunday Group (Reg. No. W3147).

Males: 30–40 mm.; females: to 80 mm. long; width ·8 and ·9 mm. respectively. Cuticle at anterior end thickened into epaulette structures as described for other species of the genus; the two lateral teeth beside the mouth are rather longer than those we have seen described for other members of the genus. Oesophagus about 10·4 mm. long in male, 15 mm. long in female; anterior narrower part ·8 mm. long in male, 1 mm. in female; nerve ring just in front of middle of this part.

Male: tail blunt, ·12 mm. long. Alae ·22 mm. long, widest at level of cloaca, meeting posterior to tip of tail. Four pairs of pedunculated preanal papillae in a row reaching from level of cloaca to ·1 mm. in front of it; one pair pedunculated papillae posterior



Figs. 9-25.—9-10. *Physaloptera banfieldi*; 9. head of female; 10. bursa of male. 11-13. *Physaloptera troughtoni*; 11. head; 12, posterior end of male, ventral view, one of alae folded over tail; 13. complete bursa, lateral view. 14-15. *Contracaecum nycticoracis*; 14. head; 15. male tail. Figs. 9, 11 and 15 to same scale; Figs. 10 and 12. 16-17. *Hamatospiculum mcneilli*; 16. anterior end of male; 17, male tail. 18-19. *Hamatospiculum halcyonis*; 18. head of female, anterior view; 19. anterior end of female. 20-22. *Hamatospiculum chibiae*; 20. anterior end of female; 21. head of male, lateral view; 22. male tail; 23-25. *Diplotriaena tricuspis*; 23. anterior end of female; 24. head of female; 25. posterior end of male. Figs. 16, 19 and 23 to same scale; Figs. 17, 18, 22 and 25; Figs. 21 and 24.

to anus, not reaching edge of alae; a pair of very small sub-terminal papillae ventrally. Shorter spicule wider, ·3 mm. long; the other, narrow, needle-like, 1·25 mm. long.

Female: vulva at varying distance posterior to end of first part of oesophagus, ·8–1·3 mm. from head. Eggs about 45μ by 30μ, thin-shelled and containing larvae.

As has been mentioned, the conical projections on head of this species are larger than those previously described for species of *Hamatospiculum*, resembling more closely those of *Monopetalonema*; the spicules, however, do not resemble those of members of the latter genus.

Hamatospiculum halcyonis n. sp.
(Figs. 18–19.)

Collected by Mr. E. Troughton from between the eyeballs and roof of the mouth of *Halcyon pyrrhopygius* (type host), at Mt. Lyndhurst, South Australia (Reg. Nos. W1070, W1074, W1063), and by the same collector from the subcutaneous tissues of the neck of *Halcynon sanctus*, near Kingscote, Kangaroo Island (Reg. No. W1076).

Only females collected, varying in length from 35 to 50 mm., tapering to rounded anterior end and blunt posterior end. Head characters as for genus, the epaulette-like structure referred to by Caballero (1937, 405) being well shown in anterior view of head, but not in lateral view. Mouth almost round. Anterior part of oesophagus ·3 mm. long, posterior part 9·7 mm., in a worm 50 mm. long, i.e. oesophagus one-fifth body length. Nerve ring around middle of anterior part of oesophagus, ·8 mm. from head in worm 35 mm. long, in which anterior part of oesophagus is ·25 mm. long.

Anus just in front of tip of tail, atrophied. Tail with two minute rounded sub-terminal papillae. Eggs thick-shelled, about 25μ by 40μ.

In the absence of males it is difficult to decide definitely whether these worms belong to *Hamatospiculum* or to *Monopetalonema*. In members of the latter genus as diagnosed by Freitas and Lent (1936) there is not necessarily a pair of cuticular epaulette structures laterally to the mouth. The species figured by these authors have much larger tooth-like projections on either side of the mouth than have our specimens. We have found in other kingfishers worms similar to those described above (but belonging to different species), and since these are accompanied by males, allowing their assignment to *Hamatospiculum*, we suggest that the worms now described belong to a new species of that genus.

The species most closely resembles *H. dicruri* Tubangui, from the Philippines, differing from it in the ratio of the two parts of the oesophagus and in the size of the eggs. These differences are not great, but in view of the absence of males in our material and the difference in distribution of the hosts, it is considered wiser to place the worms in a new species.

Hamatospiculum chibiae n. sp.
(Figs. 20–22.)

From the skin of the neck of the drongo, *Chibia bracteata*, from Russell Island, Queensland (Reg. No. W1611), collected by the late Dr. W. E. Paradice. We have also identified females of this parasite from the same host species collected by the late Dr. T. L. Bancroft in the Burnett River district.

Male 17 mm. long, ·4 mm. wide; female 65 to 75 mm. long, up to 1 mm. wide. Teeth at either side of mouth very small, not conical in lateral view, but flattened and slightly bifid at tip. Five papillae at either side of mouth on cuticular thickening. Anterior part of oesophagus ·36 mm. in male, ·45 mm. in female; posterior part 6·2 mm. long in male, but is obscured in female. Nerve ring about middle of anterior part of oesophagus.

Caudal alae present, not meeting posteriorly, supported by four preanal and two postanal pairs of elongate papillae. Cloaca 70μ from tip of tail. Spicules 2·3 and ·6 mm. long with bluntly rounded tips.

In female anus sub-terminal; vulva with salient lips in region of anterior end of posterior part of oesophagus, about 1·2 mm. from head. Eggs thick-shelled, 30μ by 50μ.

This species is very like *H. halcyonis* described above. It differs in the length of the worms, the size of the eggs. It differs from *H. dicruri* Tubangui in the number of caudal papillae and in the lengths of the spicules.

Diplotriaena tricuspis Fedtsch.

(Figs. 23–25.)

From the abdominal cavity of *Cysticola exilis*, collected by H. L. White at Moa (Banks) Island, Torres Straits (Reg. No. W989).

Several specimens including males and females in excellent state of preservation. Males up to 50 mm. long, females up to 80 mm. long, both about ·5 mm. wide, i.e. relatively slenderer than most species of the genus. Head with four large sub-median papillae and just anterior and lateral to each of these a very much smaller papilla, making eight in all. Oesophagus 3·5 mm. long in male, 4 mm. in female; its narrower anterior part ·3 mm. and ·4 mm. long in male and female respectively; surrounded just behind its middle by nerve ring. Tridents as figured, with middle branch much nearer to one of laterals in each case; anterior tips pointed; whole trident about 85μ long in both sexes.

Caudal alae absent in male. On ventral surface of tail five pairs of very small papillae near mid-line, seven pairs of larger ones laterally. Longer spicule ·9 mm. long, simple, tapering to a point; the other ·6 mm. long, provided with two twisted alae.

In female anus absent; rectum degenerate; posterior end rounded; vulva ·6 mm. from head; vagina long. Eggs in vagina 30μ by 45μ.

In view of the very slight differences between our specimens and *D. tricuspis* (as described by Seurat), namely, the shorter spicules and more numerous caudal papillae in the male, and the shorter tridents, and the wide distribution of *D. tricuspis*, we consider it wisest to assign our specimens to that species. Linstow in 1897 described *Filaria tricuspis* from *Cysticola exilis* and other birds from New Britain.

Filaria (s.l.) sp.

Two cysts (Reg. No. W989) from the white-backed wren (*Malurus leuconotus*) were collected by Mr. E. Troughton at Mt. Lyndhurst, South Australia. Each contains what appears to be one very long tightly coiled worm, with length more than 60 mm. and width about ·4 mm. The internal organs have degenerated, leaving a homogeneous granular material inside the cuticle. The ends of the specimen, partly untwisted, are rounded and bear no distinguishing features. The parasite is probably a Filariid worm.

Spironoura elseyae n. sp.

(Figs. 7–8).

From a tortoise, *Elseya dentata* (Reg. No. G.11106). The material was collected in Northern Australia by G. Masters and was recorded by Krefft (1871) as *Ascaris* sp. There are five worms present, three males and two females, all in a very shrunken state. The label is in Krefft's handwriting. Such characters as can be seen lead us to assign the parasites to *Spironoura*. The distinguishing features for the species (position of vulva, size of eggs, caudal papillae of male, shape of lips) are so indefinite in the specimens that we have not been able to compare them with previously described species. Since no member of the genus has yet been reported from Australian tortoises, we deem it advisable to erect a new species for these parasites.

Males 18·2 mm.–20·8 mm. long; with vestibule 108–117μ long; oesophagus 2·55 mm. long; spicules 1·65 mm. long, massive with wide alae; tail bluntly rounded, ·3–·32 mm. long; owing possibly to the shrivelled condition, no caudal papillae were observed.

Females 12 mm. (young specimen) and 22 mm. long; with vestibule 117–130μ long; oesophagus 2 mm. and 2·34 mm. long; tail conical, pointed, about ·28 mm. long; vulva not observed.

Contracaecum nycticoracis n. sp.

(Figs. 14–15.)

From the bill of *Nycticorax caledonicus* (Nankeen heron) from the Bulli district, New South Wales (Reg. No. W3236).

Single male present 20 mm. long, 1 mm. wide. Interlabia nearly as long as lips. Oesophagus 2·6 mm. long, its appendix ·65 mm. long; intestinal caecum 1·7 mm. long, cone-shaped, voluminous. Nerve ring ·45 mm. from head. Tail ·13 mm. long, narrowing suddenly posterior to anus. At least twelve pairs of preanal papillae, one pair of papillae ventrally immediately behind anus, and two pairs laterally half-way down tail. Even in ventral view no other papillae were seen on tail. Spicules broken, part remaining in body 3·36 mm. long.

The species differs from *C. microcephalum* in the wider head, relatively shorter oesophageal appendix, and in the number of caudal papillae.

Ascaridia columbae (Gmelin 1790).

This parasite (Reg. No. W3238) was found by Mr. H. S. Grant in great numbers in the intestine of a Queen Alexandra parrot, *Polyteles alexandrae*, which had been kept in captivity at Beecroft, New South Wales. The small intestine was for the greater part of its length distended by an almost solid plug of worms. It is apparently a case of over-infestation by a helminth not normal to the host, the nematode being a common parasite of domestic pigeons.

The males are 25 to 30 mm. long, the females up to 45 mm. The spicules are 1·8 mm. long in 25 mm. worm, 2 mm. in 30 mm. worm. Anterior to each of the small papillae figured by most authors at the level of the anterior border of the sucker are three additional papillae arranged in a row reaching anteriorly about ·8 mm. from the sucker. Eggs near the vulva are 45μ by 70μ.

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SOME AUSTRALIAN INCISED STONES.

By Elsie Bramell, M.A.

(Plate iii.)

In the last few years some unusual stone objects have been added to the Australian Museum collection. They are of two main types—stones bearing longitudinal and criss-cross incisions, and stones, generally waterworn pebbles, upon which is engraved a design or figure.

Four (Pl. iii, figs. 1 to 4) are pieces of sandstone of varied colouring, and scored across with parallel or converging incisions, such as might be made in sharpening pointed implements. They were found upon a coastal midden at Boat Harbour, near Sydney, by Mr. J. Ashley. Photographs were taken and coloured replicas made of the specimens, as the original pieces remain in the possession of the finder.

A yellow sandstone artifact (Pl. iii, fig. 1), scored on three surfaces by 10, 5 and 15 lines respectively. The dimensions are 13·8 cm. long, 10·2 cm. wide, and 4·5 cm. at the thickest part. A light grey sandstone (Pl. iii, fig. 2) with roughly parallel scorings, 7 on one surface and 6 on the other. It is 13·2 cm. long, 9·2 cm. wide, and 3·75 cm. thick, and appears to be portion of a larger specimen. Pale yellow sandstone (Pl. iii, fig. 3) with 2 deep incisions on one surface only. The length is 14 cm., width 13 cm., and thickness 2·7 cm. A reddish ferruginous sandstone (Pl. iii, fig. 4), irregular in shape, and marked on one surface only by 7 grooves. It is 14·9 cm. long, 11·8 cm. wide, and 3·2 cm. thick.

A piece of sandstone (E 35254) 15·2 cm. long, 7·6 cm. wide, and 2·5 cm. thick, showing 2 converging incisions, said to be portion of a circular slab, was found at Tonkley Point, Tuggerah Lake, N.S.W., by Mr. Roy Mackenzie. This type of grooving is reminiscent of that found over wide surfaces of rock engravings on a large scale, such as those at Delamere, Northern Territory.

A piece of stone (E 45302, Pl. iii, fig. 5) from Dubbo, presented by Mr. John Baird, measures 13·35 cm. by 5·1 cm. by 1·3 cm. The grooves number 10 on one surface, and 5 on the other. These latter grooves are shallow, broad depressions, and are considered by geological opinion to be of natural origin. It is most likely that the more numerous grooves on the opposite surface have been added by human hands, because it was picked up on an abandoned camp site, and was said by a native to have been used for sharpening bone points; one end of the stone has been worn smooth.

In the Cairns district of Queensland slabs of slate crossed with many incisions are used as grindstones, called "*morah*". The function of the grooves is said to be to drain away the poisonous juices from the seeds; these are crushed with the aid of a pestle or topstone and water into a paste, which is then dried and rubbed into flour. One of these *morah* and its accompanying topstone were described and figured by Dr. R. Hamlyn-Harris (1916, pl. vi, figs. 1–2) together with notes on three specimens in the Australian Museum. A pestle collected with one of the latter specimens (E 10100–1) appears to have been part only of the original slab; it is scored on both surfaces, which, in addition, are hollowed with use. Dr. Hamlyn-Harris declares that their distribution was limited to the district round Cairns. Rubbings of three additional *morah* in the Queensland Museum are now in our possession and indicate the range of size of these grindstones. One measures approximately 17·75 by 10 cm., another

13 by 6·5 cm., and the third 42 by 34 cm., the number of incisions varying according to the size of the stone. Again, Mr. H. O. Fletcher, a member of the 1939 Expedition to the Simpson Desert, reports that a large grindstone bearing incised lines over one surface was collected on the Mulligan River, south-west Queensland, and is now in the South Australian Museum.

It would appear, then, that the Cairns district is not the sole area where incised stones are used, for they have been found in several parts of New South Wales and elsewhere. Though no record of their particular function has come down to us, the fact that the latter were collected on middens would point to their having served some useful purpose, such as sharpening stones for shaping the bone and wooden spear points used along the coast. Mr. C. P. Mountford (1938) has published a description of eight stones engraved with straight transverse lines, the significance of which is not known, but he thinks it likely that they may have served the same purpose as message sticks.

In the ethnographical collection of the Australian Institute of Anatomy, Canberra, is an unlocalized aboriginal stone (Pl. iii, fig. 6) incised with lunate, criss-cross and parallel sets of lines, and several sets of "emu tracks"; an encircling groove at one end could indicate a connection with initiation ceremonies. The markings are strongly reminiscent of those on cylindro-conical stones or on wooden message sticks. This particular specimen is a smooth piece of grey slate.

A brief account of a waterworn pebble (E 38254) found in the Liverpool district, upon which is engraved a stingray, was published by Mr. F. D. McCarthy (1936). It was presented to the Museum by Mr. K. E. Jones. Several others similarly inscribed with naturalistic figures have since been received. One pebble (E 43909, Pl. iii, fig. 7), 8·5 by 5·1 cm., has cut upon it the outline of a tortoise with outspread legs. Another (E 43910, Pl. iii, fig. 8), 7·6 by 4·3 cm., bears the profile of an oval-shaped creature with four legs—perhaps a small mammal or an enlarged slater—it is impossible to say which. These two stones were presented by Mr. Keith Jones, who found them at Holdsworthy, New South Wales. Thirdly, a ground-edge axe of the flaked type (E 44181, Pl. iii, fig. 9) was picked up at Tingha, near Inverell, and given to the Museum by Mr. Philip Trentz. It was found to have engraved on one surface a fish, and on the other a boomerang or throwing stick; it is 9·5 cm. long and 7 cm. wide.

A small polished oval waterworn pebble from Maroubra, near Sydney (Pl. iii, fig. 10), measuring 4·8 by 2·8 cm., has scratched rather than engraved upon one surface an oval concentric spiral, and on the other a 20-rayed circle or "sun" figure. The stone is red.

These stones that are engraved with naturalistic or geometric designs might be placed in the category of "magic stone" on account of their resemblance to objects carried about by tribal elders or sorcerers.

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EXPLANATION OF PLATE III.

INCISED STONES.

Figs. 1-4.—Boat Harbour, south of Sydney, New South Wales.
Fig. 5.—Dubbo, New South Wales.
Fig. 6.—No locality.
Figs. 7-8.—Liverpool district, near Sydney, New South Wales.
Fig. 9.—Tingha, near Inverell, New South Wales.
Fig. 10.—Maroubra, near Sydney, New South Wales.

Photographs by G. C. Clutton.

AN AXE QUARRY AT MOOR CREEK, TAMWORTH DISTRICT, NEW SOUTH WALES.

By Frederick D. McCarthy.
The Australian Museum.

(Plate iv.)

Some years ago Mr. E. Wyndham, of Daruka Station, Moor Creek, informed me that there was an aboriginal axe quarry on his property, and in May, 1940, I was able to visit the site. The station is now owned by Mr. G. Powell, who was absent at the time of my visit. One of his employees, Mr. Dell Fisher, kindly escorted me to the quarry.

The quarry is situated on top of a high ridge, running north and south, which separates Moor Creek valley from Tamworth. At several points along this ridge are outcrops of basalt, consisting of weathered columnar slabs. The main outcrop extends for about 300 yards and is from fifteen to twenty feet in width. The flat-sided slabs vary from rectangular to trapezoid, occasionally triangular, in section, and range from small pieces to columns several feet long. The stream-like outcrop is broken at several points where there are depressions in the mass of stones; several of these depressions occur beside one end of the outcrop. Places at which the aborigines worked are denoted by patches of flakes, among which, or nearby, hammerstones were found (Plate iv, fig. 6).

The artifacts collected are as follows:

Group A.—E.48647, 48652–57, 48659–63. (Pl. iv, fig. 1).

These are pieces of basalt, with one or two lateral edges chipped. They are 11–17 cm. long, 7–11 cm. wide, 2–5½ cm. thick, and 9 oz., 16–40 oz. in weight. Three have been broken and discarded. They may represent the first stage in the flaking of an axe-blank, and those pieces which proved unsatisfactory for axes were probably used as scraping and cutting implements.

Group B.—E.48640–41, 48643–44, 48646, 48648.

This group apparently represents the second stage in preparing the axe-blank. It consists of pieces of basalt, quadrangular and trapezoid in section, 13–23 cm. long, 5–11 cm. wide, 4½–6 cm. thick, and 1½–5½ lb. in weight. They are flaked along three or four of the edges. E.48642 has a battered end as though used as a hammerstone. The ends on most of these specimens are roughly flaked, especially E.48642 and E.48648, but are not bevelled.

E.48639 (Pl. iv, fig 2) is 35 × 10 × 3–7 cm., and weighs 8 lb. It is trapezoid in section and is unusually large. Three edges are flaked from two faces, and the whole of the thick side has had the crust flaked away. The two ends are rough, and on one the semi-circular edge has been flaked. The size of this "blank" suggests that it is not an axe, but it could be a grooved conical stone (McCarthy, 1939) in the making; I was told by Mr. Fisher that one of the latter implements (which hitherto have not been recorded north of Oberon) was ploughed up by a local resident of Moor Creek valley, who gave it to the local school, but inquiries failed to locate it.

Group C.—E.48650–51, E.48685. (Pl. iv, figs. 3–4.)

This group represents a further stage in preparing the axe-blank. The specimens are 11½–17 cm. long, 5½–8 cm. wide, 5–6½ cm. thick, and weigh 1¾ lb. They are all shaped to a bevelled blade at one end. On E.48651 the blade has been shaped along both sides

and one end, but the butt end is broken off. On E.48649 (28 oz.) advantage has been taken of the two sloping surfaces of a wedge-shaped piece of stone to form a blade where they meet. E.48685 is an axe-blank from Moor Creek, and is of the same material as at the quarry. It is $9\frac{1}{2} \times 7\frac{1}{2} \times 2\frac{1}{2}$ cm., and weighs 8 oz. It is a typical example of the carefully worked lenticular axes from the Tamworth district.

The final shaping and the grinding of the blade were not done on the quarry, but were carried out in the camp or some convenient place near water. This custom was followed at the quarries at Mt. Foster and Mt. Harris (Towle, 1939, pp. 206–9), and at Mt. William, Victoria.

Group D: Hammerstones.—E.48642, E.48645, E.48668–76. (Pl. iv, fig. 5.)

The specimens in this group are similar in form to those of group B, but they have been used to such a degree as percussion stones that they cannot be considered as potential axe-blanks.

E.48672–73 and E.48675–76 each have one end battered to a flattened face with rounded edges; they are 12–13½ cm. long, 7–8 cm. wide, 4–5 cm. thick, and weigh from 1½–2 lb. E.48676 is only the hammered end of the tool. They are quadrangular and trapezoid in section. E.48668 and E.48674 have the percussion face along a bevelled edge formed by flaking at one end; they are 10 and 17 cm. long, 1¾ and 3 lb. in weight.

E.48670–71 have the percussion edge along the thin lateral side of trapezoid pieces of stone, so that the weight is employed to full advantage. They are 12 and 14 cm. long, 1½ and 2 lb. in weight. E.48669 is a small fabricator with a lateral percussion face. It is 9 cm. long, and 8 oz. in weight.

Group E: Flakes.—E.48664–67.

These vary in size up to 11 × 7 cm. Some of the large examples are chipped along one edge. One flake, 10 × 6 cm., has a well chipped concave edge along one side. They are flakes struck off the axe-blanks in the process of shaping.

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EXPLANATION OF PLATE IV.

Fig. 1.—Example of Group A. E.48663.

Fig. 2.—Example of Group B. E.48639.

Figs. 3, 4.—Example of Group C. E.48650 and 48685.

Fig. 5.—Example of Group D. E.48642. Hammerstone, waisted.

Fig. 6.—Portion of the outcrop of columnar basalt, showing a place where the stone-axe makers worked. Note the flakes among the boulders.

Photographs by G. C. Clutton (1-5) and F. D. McCarthy (6).

TWO PEBBLE INDUSTRY SITES OF HOABINHIEN I TYPE ON THE NORTH COAST OF NEW SOUTH WALES.

By Frederick D. McCarthy,
The Australian Museum.

(Plates v–vi.)

During a reconnaissance on the north coast of New South Wales I examined two occurrences of water-worn pebbles, at Yamba and Crescent Head, which had been quarried for the manufacture of Hoabinhien I type implements. Their importance lies in the fact that each site presents a single industry unmixed with the numerous extraneous influences found on kitchen-middens south of Port Macquarie. Moreover, it appears probable that neither site has been visited previously by collectors.

Yamba.

Yamba Point, at the south end of the surfing beach, is flattened and considerably eroded; although the greater part of it is covered with wind-blown sand, patches of dark soil are exposed, and large weathered blocks of sandstone, fantastically shaped, project here and there. Several acres of this headland are covered with water-worn stones of all sizes from small pebbles up to boulders which extend down the beach into the water; a layer of pebbles occurs in the sand dune skirting the shore end of the headland, and where the sand has blown away the pebbles lie upon the eroded surface of a "raised beach". Implements were collected over the whole area covered by the pebbles, and the following is a description of the various types.

Cores.—E.48707–12. Originally spherical or thick pebbles from which flakes have been struck; two are irregular in shape and two are roughly triangular with vertical faces on two sides. They are 8, 10–15 cm. in length. 48712 (Pl. vi, fig. 1) is the only *horse-hoof* core, and the edge of its flat ventral cleavage surface is carefully chipped all round; it is 12½ × 10 × 6 cm., and weighs 33 oz. 48713 has a domed top slightly chipped.

Pebble Core Implements.—E.48710, 48717–21, 48765. Pebbles chipped from both surfaces at one end so as to produce a bevelled blade or striking platform. On some specimens the edge of the blade end is undulating as a result of alternate flaking and they would appear to be cores; others have a comparatively straight trimmed edge, and appear to be hand axes. They are from 9 to 15 cm. long, and weigh from 20 to 36 oz.

Karta.—E.48713–4, 48797 (Pl. vi, fig. 2), 48809. Made from either the core or slice portions of a split-pebble, though all may be regarded as core implements. The working edge is chipped from the cleavage surface. 48714 has a carefully trimmed edge along the two lateral margins and the curved end, and only an island of the dorsal crust remains. They are from 8½ to 11½ cm. in greatest diameter, 2½ to 5 cm. in thickness, and from 8 to 17 oz. in weight.

Uniface Pebble Implements.—This type constitutes the majority of the implements at Yamba, and comprises five varieties:

A. Working edge on one lateral margin (Pl. vi, fig. 3). E.48722–49, 48751–62, 48764, 48789. 43 specimens. The working edge varies from concave to convex, and on some specimens is irregular and gapped. The trimmed "nose" occurs on 48761. Secondary chipping has been carried out on many examples, especially those made of fine-grained stone. The series range from 7 to 18 cm. in length, 5½ to 11½ cm. in width, 2 to 6 cm. in thickness, and from 6 to 44 oz. in weight.

B. Working edge on one end. E.48766–73. 8 specimens (Pl. vi, fig. 4). As with group A, the working edge varies from concave to convex, although it is generally regular and even. 48768 is triangular in shape. They range from 5½ to 13½ cm. in length, 6 to 9½ cm. in width, 1½ to 4 cm. in thickness, and 4 to 26 oz. in weight.

C. Working edge on one end and on one or both lateral margins (Pl. vi, fig. 5). E.48715, 48748, 48750, 48763, 48793–94. 6 specimens. The trimmed "nose" occurs on 48763. Some have a steep-faced working edge, but on 48793–94 the chipped portion is almost parallel to the crust surface beneath it. They range from 6 to 11½ cm. in length, 5½ to 9 cm. in width, 2½ to 5 cm. in thickness, and 6 to 33 oz. in weight.

D. Trimmed on edge of cleavage surface. E.48779–87, 48790–92, 48795, 48798–804, 48806, 48808. 22 specimens. Made from split pebbles, 16 from the core portion, and 6 from the slice part, although all may be regarded as core implements. Oval and irregular oval in shape. The edge may be partly or wholly trimmed, and on some examples is steep-faced. 48781 is a large slice, 17 × 10 cm., and 22 oz., on which the pronounced bulb of percussion occupies almost half of the cleavage face which slopes away to a long chipped edge. They range from 7 to 18 cm. in length, 6 to 11 cm. in width, 2 to 4½ cm. in thickness, and 6 to 22 oz. in weight. This group is trimmed from the crust surface, but differs from the *sumatra*-type in having an unworked cleavage surface.

E. *Sumatra*-type.[1] E.48774–76, 48783, 48796, 48805, 48807. 7 specimens. One surface of the pebble is flaked, and its margin is trimmed. This surface is convex and the crust has been flaked away on all examples. On some of the specimens a ridge on the crust surface forms a keel, which assists in gripping the artifact, and this keel is preserved on the worked surface, so that they are roughly quadrangular in section. 48777, the thickest specimen, has two faces on its worked surface, and weighs 35 oz. 48774, 48783, and 48796 (Pl. vi, fig. 6) are the finest examples, carefully trimmed all round their margins. 48774 is thick at one end, from which it tapers to an axe-like blade at the other end. They range from 10 to 14 cm. in length, 5½ to 11 cm. in width, 2 to 5 cm. in thickness, and 16 to 26 oz. in weight.

Flakes.—A large number of flakes were noted and a series collected. None are trimmed on the edges. Most of them were probably struck off the pebbles in the making of the implements, but the occurrence of cores on the site suggests that the flakes had some use.

Hammerstones.—Only one specimen was found (E.48812). It is a round pebble 14½ × 9 × 3½ cm., and weighs 28 oz. Several flakes have been struck off one surface as a result of use.

Summary.—The following artifacts were collected: 6 cores (one of the *horse-hoof* type), 7 pebble core implements, 4 *karta*, 86 uniface pebble implements (including 7 *sumatra*-types), 1 hammerstone, and a series of flakes. The scarcity of *karta*, *horse-hoof* cores, and hammerstones is noteworthy.

Crescent Head.

There are two stations at Crescent Head, a quarry on the headland and pippy middens along the beach.

The Quarry. (Pl. v, fig. 1.)

Crescent Head consists of tuffs, sandstones and shales in which rhythmical deposition is marked; the tuffs and sandstones vary greatly in colour, texture and composition, and inclusions of grey shale are abundant in the sandstones (Voisey, 1934, p. 340.). Masses of stone are pounded off the headland by the sea and washed

[1] The name *sumatra*-type was given to this variety of the uniface pebble implements by P. V. van Stein Callenfels as a result of the excavation of kitchen-middens in north-east Sumatra during 1925 and 1926. In these deposits the *sumatra*-type was almost the only type of artifact found.

on to the two beaches where they eventually become smooth and water-worn. The smooth stones cover the small beach between the two headlands, extend across a narrow spit (where they are covered with sand and grass), and are massed for about one-quarter of a mile along the edge of the reserve at the southern end of the beach; as at Yamba, their size varies from small pebbles to large boulders.

The aborigines quartered suitable pebbles by percussion and used both the core and large flake portions in the making of their implements. Apparently the pebble boulders were employed as pestles to split the pebbles. The implements collected are as follows.

Cores.—Owing to their great size, only two specimens were collected, although pebble cores are abundant on the site. E.48815 (Pl. vi, fig. 7) is 22½ × 23 × 8½ cm., and weighs 8¾ lb.; a large slab has been struck off each side, and their size is indicated by the negative impression on the core. E.48816 is 18 × 15 × 5½ cm., and weighs 5 lb. They are both oval, elongate pebbles of the slender type. One core was noted as being the same length as E.48815, but twice as thick.

Pebble Core Implements.—E.48818–24, 48826 (Pl. vi, fig. 8). Pebbles chipped from both surfaces to produce a bevelled blade at one end or on one lateral margin. 48821 is one portion of a split pebble and is 18½ × 14 × 8 cm., and weighs 4½ lb.; alternate flakes have been struck off its edge, leaving a scalloped line, as though it were a core. 48822, a similar type, is 16 cm. long and weighs 3 lb. 48819–20 and 48826 are small examples from 10 to 13 cm. long, and weigh from 12 to 18 oz. The trimmed edge on some examples is regular and appears to have been used.

Karta.—E.48823, 48825, 48829–34 (Pl. vi, fig. 9). Split-pebble implements, trimmed on the edge of the crust surface from the cleavage face. 48829 is keeled and shoe-shaped and is chipped round the tongue-shaped end; it is 20 × 13 × 6½ cm., and weighs 4 lb. 48830–31 are irregular types, both 13 cm. in diameter and 5 cm. thick, and weigh 1¾ lb. and 2¾ lb. respectively. 48832–33 have lateral blades and are 10 and 11 cm. long. 48834 is a tanged slab, 18 × 13½ × 4 cm., weighing 2¼ lb.

Uniface Pebble Implements.—E.48827–28, 48835–42, 48867. As at Yamba, they consist of pebbles which have been split by percussion and both the core and slice sections used as implements. The bulb of percussion is pronounced on some of the latter type. The edge is only partly trimmed on the cleavage surface, mainly from the crust face, though a few flakes have been struck off, either by intention or as a result of use on the edge of the crust face on several specimens. 48827 is a lateral type with a tongue-shaped projection between two concave edges forming the working edge. Three have been rolled by the waves. There are no *sumatra*-types in this group. They vary from 8 to 18½ cm. in length, 6½ to 14 cm. in width, up to 4½ cm. in thickness, and 1 to 3⅜ lb. in weight.

Flakes.—E.48845–52. A series of large flakes with trimmed margins, varying from irregular quadrangular to oval in shape. They are from 8 to 12 cm. in length.

Beach Middens.

A long beach extends northward from the quarry at Crescent Head. A small lake, which is usually closed, has its entrance at the southern end of the beach, and near its northern shore is an aboriginal burial ground in the sand dunes. About one mile along the beach a series of middens begin; they consist almost entirely of pippies (*Plebidonax deltoides* Lamarck) and extend for another mile or more along the dunes. In some places they are built up into conical heaps about a metre in thickness, and there are extensive areas of scattered shells (Pl. v, fig. 3). Fireplaces, which are numerous, are made up of small pebbles washed up on the beach; these stones are now red as a result of being burnt, and if crushed would be suitable for use as pigment. The aborigines took the pippies to the fireplaces, extracted the animal and roasted it in the ashes. The late T. Dick had a series of photographs showing the aborigines of Port Macquarie collecting pippies on the beach and roasting them in the fires. Pippies are still gathered in quantities on Crescent Head beach by local fishermen.

Not more than several dozen artifacts were observed on these middens. They were all carried by the aborigines from the quarry and were not made from the small thin

pebbles scattered along the beach. It may be concluded, therefore, that they are all implements, and not blanks or rejects.

Horse-hoof Core.—E.48868. The flat ventral surface is pebble crust, and its edge is chipped along one side. It is 10½ × 7 × 5½ cm. Weight 19 oz.

Karta.—E.48857–62 (Pl. vi, fig. 10). Similar to those found on the quarry. Several specimens are discoidal and wedge-shaped, chipped along the lower edge of the thick side and along the thin edge. They are 10–15 cm. long, 7–12 cm. wide, 3½–6½ cm. thick, and weigh 14–30 oz.

Worimi.—E.48863 (Pl. vi, fig. 11). A large crescentic implement, triangular in section. One of the sloping surfaces is a cleavage face, the other a crust surface. The thick crescentic side is carefully shaped and bears percussion marks. It is 16½ × 11 × 7 cm., and weighs 44 oz. Artifacts of this type, made of porphyry and chert, form a conventionalized type in the Newcastle district and in the neighbouring north and south coastal area. As they are abundant in the territory of the *Worimi* tribe, the adoption of this name has been considered advisable.

Sumatra-type.—E.48856 (Pl. vi, fig. 12) is shoe-shaped, keeled and triangular in section. Several large flakes have been struck off the side and end of the crust surface. On one side of the keel is a flat cleavage face and the edge it forms with the keel is heavily work with stepped chipping. The other face of the keel is worked, and the edge it forms with the ventral crust surface is well chipped. One end is bevelled from the keel to the end of the crust surface, and its edge is also well used. It is 15 × 7 × 5½ cm., and weighs 24 oz. On 48867 the crust surface is flattened, the worked surface is convex, and one edge is chipped. Several other uniface pebble implements were noted but not collected.

Flakes.—E.48853–54. Side scrapers made from pebble flakes 5 and 8 cm. long. A number of unchipped flakes were collected.

Ground-edge Axes.—Only three specimens were collected, one on the quarry and two on the middens. They are made from split pebbles, and are actually uniface pebble implements with a ground edge at one end. On each specimen the blade is ground on both faces. E.48866 is 13½ × 9 × 3½ cm., and weighs 20 oz. 48865 is 12 × 7½ × 4 cm., and weighs 17 oz. Both have a very narrow blade. On 48814, from the quarry, the blade is ground from 1½ to 2½ cm. wide. It weighs 12 oz. It is probable that local residents have collected other ground-edge axes on the quarry and beach sites.

Summary.—The following artifacts were collected on the two stations: 4 cores (one of the *horse-hoof* type), 8 pebble core implements, 14 *karta*, 1 *worimi*, 14 uniface pebble implements (including 1 *sumatra*-type), 3 ground-edge axes, and a series of flakes. Points of interest are the absence of pebble hammerstones, the scarcity of *horse-hoof* cores, and the high proportion of *karta*.

Relationship of Weight to Length-Breadth Index.—The *karta* and uniface pebble implements from Crescent Head range from 13 to 40 oz., with one at 67 oz.; there are 8 at 13 oz,. and 19 from 20 to 40 oz., so that there might be said to be a light series and a heavy series. The length-breadth indices reveal the large size of the implements, which range from 46 to 100; there are 3 between 46 and 65, 16 between 70 and 85, and 6 between 90 and 100. At Yamba the *karta* and uniface pebble implements range from 4 to 44 oz.; the peak is from 12 to 20 oz., there being 79 specimens from 8 to 24 oz., 7 from 28 to 44 oz., and 3 at 4 oz. The length-breadth indices range from 43 to 100, with a decided peak at 65; there are 19 between 43 and 55, 33 between 60 and 70, 31 between 75 and 90, and 6 at 100. Although the series is a light one, its length-breadth ratio is comparatively high.

Affinities.—In 1931 Tindale and Maegraith described a culture from Kangaroo Island which consists of *horse-hoof* cores, *karta*, *sumatra*-types, trimmed discoidal flakes and dual pebble hammer and nether stones. The Yamba and Crescent Head sites agree closely with the Kangaroo Island culture in the types of artifacts, although they have local features which are in conformity with the variations of the implements present in South Australian and Tasmanian occurrences of the Hoabinhien I type culture. The

main point of difference lies in the presence of pebble core-implements and the scarcity of horse-hoof cores and pebble hammerstones at Yamba and Crescent Head.

In 1937 Tindale discussed the relationships of the Kangaroo Island culture, pointing out the similarities and local variations at Fulham, Hallett's Cove, and in Tasmania; he concluded that the Kangaroo Island industry in South Australia is related to cultures of the "Upper Palaeolithic of Malaya". I pointed out in 1939, 1940*a* (p. 39) and 1940*b* (p. 262), as a result of an examination of museum collections in Java and the Malay Peninsula during 1937–38, discussions with delegates at the Third Congress of Prehistorians of the Far East, Singapore, 1938, and literature on the subject, that the Kangaroo Island industry is identical with Hoabinhien I of Indo-China, Malay Peninsula, and Sumatra; this culture is tentatively assigned by prehistorians to the beginning of the mesolithic period of southern Asia and Malaya.

Hoabinhien I Implements on the New South Wales Coast.—It is noteworthy that from the neighbourhood of Port Macquarie northward there is a predominance of Hoabinhien I implements. The Australian Museum has series from Coff's Harbour, Clarence River, Yamba and Crescent Head, and specimens from the Manning River, Byron Bay and Tallow Beach. Jackson (1939, figs. 1–3) has recorded them in the Point Cartwright district, Moreton Bay. The Crescent Head beach station indicates that the use of these implements survived on the north coast till the British occupation, although ground-edge axe techniques diffused into the area.

South of Port Macquarie, to the Victorian border and beyond, Hoabinhien I implements occur on numerous coastal middens, where they are intermixed with the *elouera* industry, bone implements, ground-edge axes, incised pebbles, mortars and pestles. In the Newcastle district hand-axes made of large pieces of chert and porphyry, for which the name *worimi* is proposed, seem to have taken the place of the pebble implements.

The axe of the type found at Crescent Head, described on p. 24, is a uniface pebble implement ground at one end, on one or both faces, to form a blade. In the Australian Museum collection there are examples from Victoria, eastern New South Wales, and Queensland. It is probable that old *sumatras* and other pebble implements lying about on the quarry-sites and middens, and those in use at the time, were transformed in this way to ground-edge axes, and they would appear to be a transitionary stage in the use of the latter technique in those areas where Hoabinhien I implements were used. Thorpe (1932, p. 307, Pl. xxvii, fig. 2) also arrived at this conclusion.

Conclusion.—The Yamba and Crescent Head sites represent Hoabinhien I type industries. The south-east Australian and Tasmanian occurrences of this industry form an extension of the Hoabinhien I culture from southern Asia and Malaya.

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EXPLANATION OF PLATES.

PLATE V.

Pebble industry site on Yamba Point, Yamba.

Fig. 1.—General view.

Fig. 2.—Portion of the eroded surface of the "raised-beach".

Pebble industry site at Crescent Head.

Fig. 3.—View of the headland and accumulation of water-worn boulders along the edge of the Reserve.

Fig. 4.—Ground-edge axe (E.48866) *in situ* among pippy-shells scattered on the beach middens.

Photographs by F. D. McCarthy.

PLATE VI.

Pebble industry site on Yamba Point, Yamba.

Fig. 1.—Horse-hoof core. E.48712.

Fig. 2.—*Karta*. E.48797.

Fig. 3.—Uniface Pebble Implement. Group A. Lateral working edge. E.48728.

Fig. 4.—Uniface Pebble Implement. B. Working edge at end. E.48768.

Fig. 5.—Uniface Pebble Implement. C. Working edge on side and end. E.48715.

Fig. 6.—Uniface Pebble Implement. E. *Sumatra*-type. E. 48796.

Pebble industry site at Crescent Head.

A. Implements from quarry.

Fig. 7.—Large pebble core. E.48815.

Fig. 8.—Pebble core implement. E.48819.

Fig. 9. *Karta*. E.48831.

B. Implements from beach middens.

Fig. 10.—*Karta*. E.48859.

Fig. 11.—*Worimi*. E.48863.

Fig. 12.—*Sumatra*, keeled and shoe-shaped. E.48856.

Photographs by G. C. Clutton.

THE PETROLOGY OF THE FIVE ISLANDS, PORT KEMBLA, NEW SOUTH WALES.

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(Plate vii and Figures 1–2.)

Introduction.

Petrological notes were supplied to Davis, Day and Waterhouse for use in their paper (1938) on the ecology of the Five Islands. Subsequent work necessitates some modification of the views then expressed.

Islands I and II.

Harper (1915, p. 303) considered that Islands I, II, III, and V are composed of either the Dapto-Saddleback flow (popularly called dolerite) resting on red tuffs, or entirely of tuffs. Islands I and II, however, consist entirely of Dapto dolerite showing a pronounced rusty red colour on the weathered surface.

From examination of this rock in the Port Kembla Government Quarry, Browne and White (1929) enumerated the following types in descending order: A. Dapto-Saddleback trachybasalt. B. Deuterically altered trachybasalt. C. An intrusion from the same magma crystallizing under different conditions, with no completely unaltered type to be seen. D. A rock usually pinkish in colour and heavily impregnated with carbonates. This is type C in an advanced state of alteration. The first two types are seen on Island II and the whole four occur on Island I. The field relations are the same as in the quarry, though not so well exposed. In the following descriptions all numbers prefixed by DR refer to specimens in the Australian Museum collection, while other numbers denote rocks in the Mining Museum. Textural terms are used according to Johannsen (1931).

Field Occurrence.

Type A (DR 4204). A black rock with a resinous lustre, showing an abundance of glassy felspar and black augite phenocrysts. On a weathered surface these phenocrysts stand out in marked relief. This type constitutes by far the greatest part of rock exposed on Islands I and II.

Type B (DR 4203). This is the trachybasalt that has suffered deuteric alteration. The groundmass is of a dark grey colour and the felspar phenocrysts have lost most of their glassy lustre and are dull greenish white in colour. The augite phenocrysts are unchanged. Exposures of this type are found as scattered masses throughout type A. These exposures are nearly all found below the ten foot contour line and some extend right to sea-level. There is no sharp line of demarcation between them and the surrounding type A. Evidently, as in the quarry, the upward limit of deuteric alteration is quite irregular. In a small ravine on the north coast of Island II some 10 chains east of the isthmus which joins the two islands, a small dome-shaped mass of type B protrudes up into type A. Judging by the comparative scarcity of outcrops and by the comparatively small extent of each outcrop the deuteric solutions had almost reached the limit of their activity.

In the centre of the mass forming the isthmus there occurs a light greyish brown rock (DR 4206) lighter in colour than the usual type B. This type is unrepresented

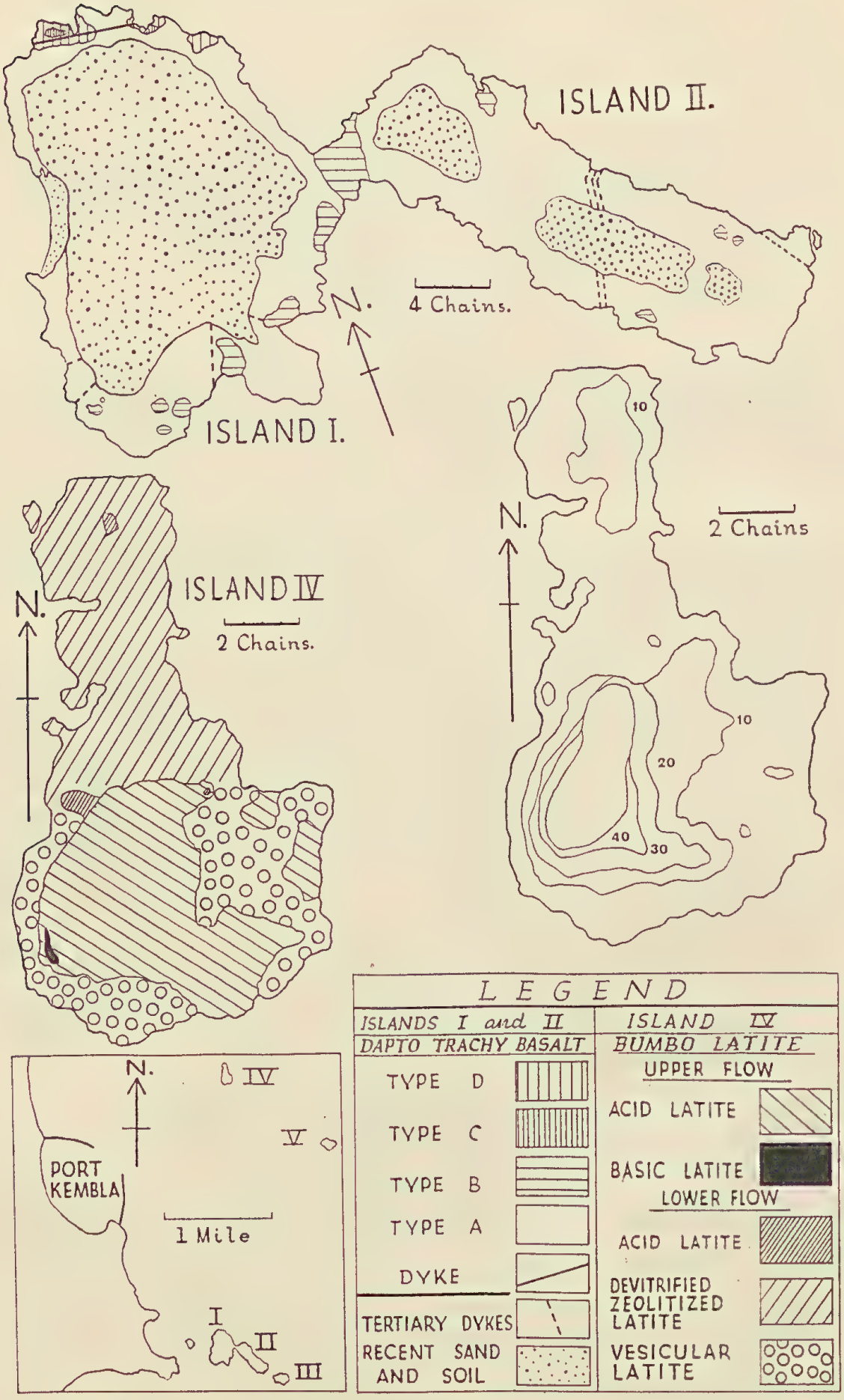

Fig. 1.—Geological map of Islands I, II and IV. Contour map of Island IV (after Davis, Day and Waterhouse), and locality map.

in the quarry. It is crowded with stout phenocrysts of greyish white felspar and black augite that shows tiny veins of chlorite. In the centre of some of the augite phenocrysts chlorite-lined cavities are commencing to form. This supports Browne's view "that in certain cases the cavities may be enlargements of spaces once occupied by olivine or augite, minerals susceptible to attack by deuteric solutions" (Browne and White, 1929, p. 315). Cavities completely filled with chlorite and some few with prehnite are seen. Prehnite has been recorded from this flow at Port Kembla by Card (Harper, 1915, p. 301).

Another rock unrepresented in the quarry is dark in colour with brownish-yellow phenocrysts of felspar resinous in appearance (DR 4201). This occurs on the north coast of Island I about 7·5 chains west of the isthmus, and grades imperceptibly into the trachybasalt. It also appears to grade down into representatives of type C which is not in accord with observations in the quarry where a recognizable boundary was seen between types B and C.

Type C is of very limited occurrence, being found as two small outcrops overlying type D on the north coast of Island I. The least altered member of this intrusive type as described by Browne from the quarry (Browne and White, 1929, p. 305) has a dense blue-black groundmass in which are set light coloured semi-opaque plagioclase phenocrysts. This was not seen on the islands. Browne (Browne and White, 1929, p. 313) also mentions that this dark intrusive rock grades into a chocolate coloured type. This, occurring both as a dark coloured (DR 4245) and a light coloured variant (DR 4197), was found on Island I.

Type D. Underlying these chocolate coloured rocks are the heavily calcitized types representing the intermediate and extreme stages of alteration of type C. In the absence of sections it is difficult to say where type C ends and type D begins. A greyish white rock (DR 4200) with milky white felspar phenocrysts represents the intermediate stage of alteration, while the extreme stage is shown by DR 4198, a rock with a dark purplish pink groundmass in which white felspar phenocrysts entirely replaced by calcite stand out. One irregularly shaped cavity, about three inches in greatest length, was filled with clear glassy quartz and calcite. A few smaller cavities were filled with glassy quartz and one with a white pulverulent leptochlorite.

A thin dyke (DR 4196) which has rather a sinuous course intrudes both type D and the normal trachybasalt on the north-west corner of Island I. The weathering of this dyke has produced a well-marked ravine (Davis, Day, and Waterhouse, Plates xv and xvi). It is a dense fine-grained rock and for part of its course is a light greenish grey colour. It suddenly changes to dirty white. It evidently accompanied the intrusion of type C.

Three basalt dykes with slender porphyritic felspars intrude the unaltered trachybasalt on the north side of Island II and pursue parallel courses across to the south side where, however, only two are to be seen. Their strikes are influenced by joint planes. Other dykes, basaltic in appearance, were noted on both islands.

A small block of a dense, black, siliceous, fine-grained sediment was seen included in the normal trachybasalt.

Petrography.

Type A (DR 4204). This corresponds exactly with the descriptions given by Card (Harper, 1915, p. 301) and Browne (Browne and White, 1929, p. 308). The chief features are: abundant labradorite phenocrysts, perfectly fresh, with orthoclase rims and up to 5 mm. in length; augite phenocrysts, quite fresh and up to 3 mm. in length; pseudomorphs of yellowish or green iddingsite and chlorite after olivine. Stout labradorite prisms, fresh tabular pieces of augite, interstitial chlorite, magnetite, and an abundance of slender apatite needles constitute the orthophyric groundmass with average grainsize about ·3 mm.

Type B (DR 4203, 4205, 4212). This closely resembles the type mentioned by Browne (Browne and White, 1929, p. 310) as showing an intermediate stage of deuteric

alteration. The labradorite phenocrysts are albitized and sericitized, but nowhere is there any evidence of the pale green augite having been completely replaced by carbonates as in some of the quarry specimens. In fact calcite is quite scarce in the groundmass. The augite is quite fresh, at most being slightly chloritized. The iddingsite after olivine has remained unaltered except in DR 4212 where the pseudomorphs consist entirely of chlorite.

A type of iron ore in the form of rods, dots or dendrites is present in all these slides, mostly fringing the groundmass augite. This is mentioned by Browne (Browne and White, 1929, p. 312) as occurring in the quarry in a finer grained phase of type B, an accompanying feature being the absence of orthoclase rims surrounding the plagioclase phenocrysts. In the Island slides the grain size is no finer and only in DR 4212 are the orthoclase rims missing.

In DR 4206, the exceptional type showing prehnite in the hand specimen, the felspar phenocrysts are completely albitized and heavily kaolinized, but sericitization, so common in other type B rocks, is completely absent. The prehnite, occurring as radiating masses, partially replaces the albitized felspar phenocrysts (Plate vii, fig. 1). Prehnite has been recorded as replacing felspar in the pegmatitic phase of the Prospect intrusion (Browne, 1925, p. 242). Fresh augite is still to be seen. Browne (1923, p. 282, and 1925, p. 244) records other examples of augite remaining unaltered despite the severe alteration of other minerals. Olivine is completely converted to chlorite. Green pleochroic chlorite is plentiful throughout the groundmass and also forms a partial border to the prehnite masses.

Cavities are present lined with chlorite and aggregates of tiny titanite (?) granules. The filling is an interlacing mass of tiny green pleochroic amphibole laths. This mineral occurs as the main constituent of a hornfels on Island IV; therefore these amphibole filled cavities are regarded as sedimentary inclusions.

In DR 4201, the other exceptional type, a curious feature is shown. The labradorite phenocrysts are perfectly fresh and show no trace of albitization, sericitization or kaolinization, although there are present in minor quantities, chlorite, and veinlets and granules of iron stained calcite. The orthoclase rims to the phenocrysts are missing. The groundmass felspars are wholly or partly replaced by calcite. Fresh augite and olivine are completely replaced by calcite and chlorite. This specimen shows every type of alteration seen in quarry specimens of type B from near the contact with the intrusive type C, with the important exception that the felspar phenocrysts have scarcely suffered any deuteric alteration. Browne (Browne and White, 1929, pp. 331–2) has postulated that after the consolidation of both types A and C, post-magmatic solutions advanced in two waves, an earlier soda-rich and a later carbonate-rich fraction. One can only suggest that the onslaught of the soda-rich fraction was sporadic and that it was missing in this particular place.

Type C (*DR 4245, DR 4197*). These chocolate coloured variants show yellowish pink felspar phenocrysts and chlorite-filled cavities. The phenocrysts are completely albitized. They are also kaolinized and calcitized. Microphenocrysts of felspar stand out in a groundmass heavily pigmented with plumose patches of hematite. The augite and olivine phenocrysts are entirely replaced by calcite and granular quartz. In the lighter coloured chocolate variant there is a decrease in hematite and an increase in calcite, colourless chlorite, and quartz aggregates. Cavities are present lined with calcite and filled with colourless chlorite and/or sericite.

Type D. In the greyish white rocks (DR 4195, 4200) hematite is entirely absent and the felspar phenocrysts much encroached on by calcite stand out in a groundmass consisting almost entirely of colourless chlorite and calcite with few traces of felspar. Some of the cavities are lined with siderite.

In DR 4198, which shows the extreme type of alteration, the phenocrysts of felspar are entirely replaced by calcite, colourless chlorite, and granular quartz. Tiny dots of hematite are abundantly disseminated throughout the calcite-rich groundmass.

One noteworthy feature in all of these type C and D rocks is that sericite is practically absent as a direct alteration product of the felspar. However, the felspars are all heavily kaolinized, most probably due to deuteric action.

The question of the iron ore in types C and D is of interest. Magnetite is practically absent, and hematite is present in the reddish types. A third mineral shows an intergrowth similar in appearance to the Widmanstätten figures shown by some iron meteorites on etching. The laths which fill the octahedral partings in what was once presumably magnetite are dark yellowish or greenish brown in transmitted light and are only semi-translucent. In reflected light they are whitish yellow in colour and are taken to be leucoxenized ilmenite. Magnetite remains occasionally as a filling between the laths or may occur on the edge of the crystal as a dense granular border. Colourless chlorite sometimes with calcite appears as a filling between the laths (Plate vii, fig. 2). In one instance a cubic arrangement of the laths was noted, a hollow square of magnetite remaining set in leucoxene. The shape of some of these crystals suggests that they may originally have been olivine.

This process is due to the unmixing of a solid solution of ilmenite and magnetite (Schwartz, 1930, Fig. 4, and Edwards, 1938, Fig. 8), subsequent deuteric alteration having almost completely removed the magnetite and converted the ilmenite to leucoxene.

The thin dyke which intrudes type D is very much calcitized. No fresh felspar remains, but what traces of texture are seen suggest that it might once have been pilotaxitic. Numerous cavities filled with pale green chlorite and calcite are present. There is an appreciable quantity of opaque material in the form of closely packed laths, slender and up to 1·5 mm. in length. These laths are aggregates of tiny granules whitish in reflected light and in some instances associated with limonite. They are usually concentrated in the vicinity of the chlorite-filled cavities. These cavities may have been formerly phenocrysts and the original material, on being replaced by calcite and chlorite, migrated but a short distance before being redeposited. There is a fair quantity of an opaque mineral scattered here and there as small fragments. This shows a bronze yellow colour in reflected light and resembles pyrrhotite.

The remaining dykes are typical Tertiary basalts consisting mainly of felspar laths and fresh titanaugite. There is an abundance of green interstitial material, some of it chlorite, and some glass set with tiny doubly refracting microlites. DR 4210 from the eastern end of Island II shows excellent pseudomorphs of pale green iddingsite after olivine. These have calcite associated with them.

Island III.

The only rock found on Island III is the normal trachybasalt (DR 4243). In one place was found an inclusion of an entirely black rock in which occasional stains of malachite could be seen. On close inspection with a powerful lens tiny specks of copper could also be distinguished. This inclusion, which is apparently a thermally metamorphosed basic xenolith, consists almost entirely of labradorite and magnetite. Small fragments of the rock are magnetic. The habit of the felspar in the slide varies. There are masses of closely interlocked stout labradorite prisms about ·25 mm. in length, showing the clouding typical of thermally metamorphosed plagioclase felspars. These masses are magnetite-free and interspersed with them are prisms of felspar about 2 mm. long. Some of these have a corroded appearance and are packed with small fragments of magnetite and apatite needles. On a casual glance they give the impression of being made up of a mass of tiny granules. This appearance is actually due to an intergrowth of two felspars, both perfectly fresh and both showing in most cases twin lamellae, the lamellae of the two sets making an angle of about 60°. There is also a small included fragment of the trachybasalt. Examination in reflected light shows numerous fragments and stringers of copper.

Island V.

A specimen from this island is the normal trachybasalt (DR 3655). Consett Davis, who collected the specimen, informs me that no other type is to be seen.

Island IV.

Harper (1915, p. 303) records this as a remnant of a purely local flow which he named the Five Islands Flow and the specimens collected were named "trachyandesite pro tem". This flow was thought to be more or less contemporaneous with the Dapto Flow. It seems as though only a flying visit was made by Harper, and since the sole landing place is on the north-west corner, probably only types in the vicinity were collected, and these are highly altered.

All the rocks on Island IV have been classified by me as latite. The predominant type has been termed in the field acid latite. It is found in various stages of deuteric alteration. There is also a limited occurrence of basic latite. For the sake of clarity those names will be used in the following descriptions.

Field Occurrence.

The northern half of the island is a slightly elevated platform mostly less than ten feet above sea-level. At the northern end there is a small area about ten feet above sea-level. On this is found one of the two freshest types of acid latite on the island. It is a dense dark bluish-grey rock (DR 4235) and occurs as patches in a more altered light greenish-grey rock (DR 4236) which is of frequent occurrence on this northern half. In this occur large masses of dark brownish calcite, irregular in shape and up to eighteen inches in length. Associated with this is the most altered type on the whole island. It is a crumbly, soft green rock (DR 4279) with abundant veins and amygdules of a faint pink to yellowish zeolite pronouncedly red along the edges. In these altered types are numerous cavities lined with massive milky granular quartz and filled with milky calcite, white or with a faint yellowish tinge. Sometimes the cavities are filled with massive quartz alone and occasional small geodes in this massive material are lined with tiny quartz crystals. This altered type of latite varies in its resistance to weathering, producing small hummocks mostly of a light reddish yellow colour (DR 4280).

At no great distance above sea-level along the western side of the cliffs which form the high southern part of the island there is a dense rock (DR 4238, DR 4278, DR 3656) of the same nature as the blue-grey acid latite except that it has a pronounced reddish tinge. This stands out as a hard bar on the softer zeolite-bearing types. Along the northern face of these cliffs at an elevation of eighteen feet there is a band of bole about one foot thick (DR 4239). This is also seen on the western face at the same level in a shallow cave-like shelter just south of the bar of reddish rock. It slopes down rather rapidly until it disappears below ground-level. Beyond the bar of reddish latite there is a reddish purple rock (DR 5868) with numerous cavities, giving place for a short distance to a rock similar in appearance but light greenish in colour (DR 5869). The reddish purple type then continues to the southwestern corner and is found between sea-level and the ten foot contour along most of the southern and eastern sides of the southern half of the island. On the eastern side quite an extensive platform has developed between these levels. In brief the low-lying parts of the island consist almost entirely of a highly altered zeolitized type mostly of a light greenish or yellowish colour in the northern half, and a less altered vesicular type with a prevailing reddish purple tinge in the southern half.

The prevailing type on the flat table-topped part of the island lying between the ten foot and forty foot contours is a dark greenish grey dense acid latite (DR 4237). Chlorite-filled vesicles, mostly small, can be discerned in all these rocks. In some they are larger and are quite a notable feature. This rock forms steep cliffs along the western edge. On the southern edge there is a more gradual descent to the low-lying, reddish, vesicular type. Along the eastern edge the descent is more gradual still. On the eastern side several caves are found in a small cliff between the thirty and

forty foot contours. Here the dark green latite has suffered atmospheric weathering and is light brown in colour (DR 4241). In this there is a large block of some altered sediment, dense and olive green in colour, with shallow cavities filled with small quartz crystals (DR 4242). In the neighbourhood small fragments of this altered sediment are included in the light-brown weathered rock. Why the dark green latite should have weathered thus on the eastern side and not on the western is not apparent.

On the south-western corner of the cliffs, about fifteen feet up, is found the sole occurrence of basic latite. It is a sheet-like mass of rock (DR 5870) which on the weathered surface has a yellowish appearance and resembles a typical basalt when fractured. It is both overlain and underlain by the dark green acid latite, and is of no great extent.

It will be seen that on this island we have the remains of two flows. The bottom flow is almost entirely altered, there being but a few remnants of dark blue acid latite. A band of bole, not visible in all parts of the island, separates it from the overlying more resistant flow, most of which is dark greenish grey in colour and comparatively

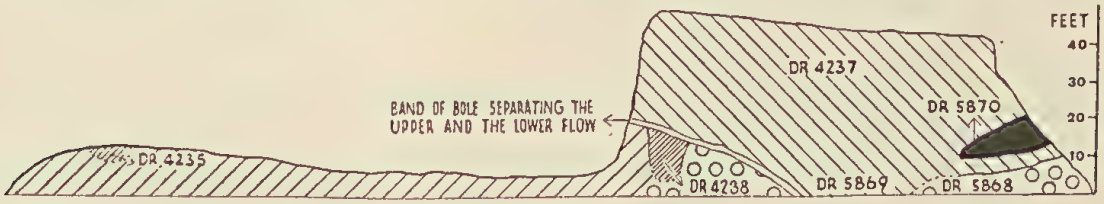

Fig. 2.—Diagrammatic section along western side of Island IV. Length of section about 15 chains. For legend see Fig. 1.

unaltered except for atmospheric weathering on the eastern cliffs and a limited formation of vesicles in DR 5869 low down on the western cliffs (see Fig. 2). In one place on the eastern side at about fifteen feet above sea-level a dark bluish grey acid latite (DR 4276) is found, the same as DR 4235 from the lower flow. This is probably a marked irregularity in the surface of the lower flow protruding through the upper flow. From the evidence shown in the diagrammatic section (Fig. 2) the junction between the flows is quite irregular. The ease with which the highly altered latites have been eroded by marine action, leaving the forty foot high cliffs standing, has caused the peculiar toothbrush shape of the island, seen most clearly from the sea on the western side.

Petrography.

Lower Flow.

Acid Latite (*DR 4235, DR 4276*). Dense dark bluish grey rock with a few small phenocrysts of felspar, and numerous small chlorite amygdules.

Holocrystalline, porphyritic; groundmass fine grained (·1–·2 mm.), unoriented. There are a few scattered phenocrysts of orthoclase and plagioclase, 1 or 2 mm. in length. The plagioclase is entirely albitized.

The groundmass felspars are slender prisms of orthoclase and plagioclase, many of them being completely albitized, while others show patchiness due to partial albitization.

Small stumpy prisms of faintly greenish augite are scattered sparsely through the field.

Although small squarish crystals of magnetite are present, this mineral occurs frequently in the form of small rods, dots, and dendritic shapes mostly forming borders to the groundmass felspar (Plate vii, fig. 5). A number of slender colourless needles of apatite are present. There are numerous small granular masses, brown in colour, often cloudy and of high R.I. These are quite a feature of all Island IV rocks and the fresher pieces strongly resemble titanite. Some of the cloudy pieces, difficult to determine, may be carbonates. There are a few small interstitial pieces of quartz.

Cavities filled with aggregates of tiny fibrous rosettes of pale green, very slightly pleochroic chlorite are common. Small interstitial masses of chlorite are plentiful in the groundmass.

Dark reddish acid latite (*DR 4238, DR 4278, DR 3656*). Very similar to the above, except that the small rods and dots of iron ore fringing the groundmass felspars are hematite and not magnetite, thus accounting for the reddish colour of the rock in the hand specimen. The chlorite is much more pleochroic, green to orange yellow; it is presumably iron rich.

In DR 3656 there are numerous cavities filled with closely packed, radiating quartz crystals. There are also cavities filled with epistilbite.

Purplish red vesicular acid latite (*DR 5868*). Somewhat weathered type, breaking with a rough fracture. The vesicular appearance is due to the amygdules having been removed by weathering, leaving only a lining of limonite to the cavities in most cases. A few small glassy patches remain. Allowing for differences due to a somewhat more intense deuteric alteration, this is the same type as DR 4238.

Glassy and devitrified acid latite (*DR 4236, DR 4280*). DR 4236 is a light-grey rock with a faint green tinge. It breaks with a rough fracture. There are quite a number of amygdules of quartz, calcite, and chlorite.

Hypocrystalline, porphyritic; groundmass fine-grained, partly cryptocrystalline, partly hyalopilitic.

There are plagioclase phenocrysts (3·5 cm.), completely albitized, much kaolinized, but with scarcely any sericite, and orthoclase phenocrysts, smaller in size. One phenocryst shows Manebach twinning, and another a combination of Carlsbad, albite and Manebach twinning.

Slender microphenocrysts of both plagioclase and orthoclase (·2 mm.) are set in a groundmass the greater part of which is glassy. There are two patches where the groundmass is cryptocrystalline and highly felspathic. The change is quite sudden, and there is no intermingling of glassy and cryptocrystalline material. There is no indication of this change in the groundmass in the hand specimen.

Cavities filled with chlorite and lined with quartz or calcite are present. One chlorite amygdule is hypautomorphic in shape (Pl. vii, fig. 4). This suggests that these cavities were originally filled with primary ferro-magnesian minerals since dissolved away, their places having been taken by deuteric minerals. One automorphic crystal of augite still remains. Granules of titanite, carbonates, and a minor amount of magnetite are also present.

DR 4280, a light reddish yellow rock, is entirely devitrified, the groundmass being heavily pigmented by tiny plumose masses of hematite and limonite.

Intensely zeolitized acid latite (*DR 4279*). Despite its altered nature, the texture is discernible in parts. The felspar is albitized. The groundmass consists of pale green non-pleochroic material at times isotropic, with small patches of quartz and calcite. Granules of titanite are abundant clustering to form borders round each zeolite amygdule. This zeolite has a (010) cleavage and the axial plane is parallel to (010), consequently no good figure was seen. It is biaxial (—), the maximum R.I. being greater than 1·516 points to epistilbite.

The massive quartz mentioned previously as filling cavities in these altered types is a curious variety. The majority of the individual grains are crowded with tiny indeterminate inclusions of high R.I., strung out in such a way as to give a sheaf-like appearance to the quartz grains. Sometimes the piece of quartz has a thin band free from inclusions running transversely across the middle. The extinction is undulose and commences from opposite sides of the crystal on each side of the band in a peculiar curved manner calling to mind a biaxial interference figure. There is ordinary clear quartz associated with this inclusion-rich variety, in places grading into it quite suddenly.

Upper Flow.

Acid latite (*DR 4237, 4275, etc.*) (Pl. vii, fig. 3). Except for the dark greenish grey colour, this rock resembles the dark blue acid latite of the lower flow. Microscopically the chief differences are that in the green acid latite there is always a fairly well defined border of untwinned felspar fringing the albitized phenocrysts, the groundmass is of somewhat coarser grain, there is a greater abundance of apatite needles, and the dendritic magnetite fringing the groundmass felspars is almost entirely absent. One example each of Baveno, Manebach and pericline twinning was noted in the phenocrysts. Albitization of the groundmass felspar usually takes the form of a patch in the centre of the crystal, leaving a well-marked border. In some cases where the outer shell is of lower R.I. than the central patch, probably orthoclase has been deposited round an already albitized plagioclase crystal. An occasional hypautomorphic chlorite crystal, with thin streaks of a more strongly pleochroic, platy variety amongst the rosetted aggregates, suggests a pseudomorph after olivine.

In some specimens abundant lenticular amygdules occur. Some consist of chlorite associated with quartz and/or calcite. Another cavity is lined with fibrous chlorite immediately followed by a thin layer of opal, and filled with radiating masses of chalcedony associated with quartz grains and calcite. The felspars near this cavity are much kaolinized.

Light greenish grey vesicular acid latite (*DR 5869*). This occurs near the base of the upper flow and has suffered more intense deuteric alteration than usual. Amygdules of chlorite, calcite, and epistilbite still remain, but weathering has removed many of them, leaving only cavities.

Hornfels of sedimentary origin included in the upper flow (*DR 4242*). This is the dense olive green altered sediment which is found as an included block. Traces of the original bedding planes can be seen and a type of minute honeycomb weathering is noticeable along the laminae. The main part of the rock is a dense mass of interlacing slender prismatic laths, pleochroic (grass green to yellow) and averaging about ·1 mm. in length. They show traces of a cleavage. They are very small and difficult to determine, but are probably an amphibole. Irregularly shaped impregnations of granular quartz sometimes intermingled with the tiny green laths are frequent. The rectangular shape of many of these aggregates suggests that the quartz has replaced some original mineral. Prismatic and basal sections of prehnite associated with the quartz impregnations were seen, the basal sections showing the anomalous bluish grey interference colours and the microcline-like gridiron structure mentioned by Iddings (1911, pp. 409–410).

The prehnite is interstitial in many places and is partly or wholly replaced by analcite, accompanied by small botryoidal masses of opal stained brown.

Weathered acid latite with included fragments of hornfels (*DR 4241, DR 5867*). A light brownish coloured rock that has suffered atmospheric weathering. There are a number of elongated cavities, but mostly the fillings have been removed, leaving a lining of limonite. Limonite has also been deposited in cracks in the rock. In the groundmass there is an abundance of limonite, and no fresh augite at all. Included fragments of the green hornfels are seen, in which epidote is sometimes present. There has been a small amount of intermingling, for here and there close to the edges of hornfels inclusions there are small groups of the amphibole laths in the latite.

It will be seen that the characteristic feature of all the above described acid latites, whether comparatively fresh or altered, is that the plagioclase shows almost complete albitization. In some cases kaolinization is pronounced and sericitization has been noted particularly in the fresh types belonging to the upper flow, but in no case is it such a marked feature as in the type B rocks from Islands I and II. It is practically absent in the specimens that have been highly altered by deuteric agents.

Basic latite (*DR 5870*) (Pl. vii, fig. 6). This is a black rock, basaltic in appearance, with a few small phenocrysts of augite and greasy-looking felspar.

Holocrystalline, porphyritic; the groundmass is fine-grained (·3 mm.), unoriented and very similar to the acid latite.

Fresh twinned labradorite phenocrysts occur in no great abundance. They are comparatively slender and only one exceeds 1 mm. in length. Some of them have an untwinned border of felspar of lower R.I., presumably orthoclase. Often tiny granules of titanite and needles of apatite are crowded along the untwinned border, while the phenocryst itself is free from inclusions. Both labradorite and orthoclase are present in the groundmass.

There are a couple of stumpy phenocrysts of pale greenish-grey augite about 1 mm. long. Small perfectly fresh crystals are scattered fairly plentifully through the groundmass, some being twinned.

A small amount of dendritic magnetite occurs along the edges of the groundmass felspars, but otherwise it occurs as the usual small fragments. There is a great abundance of slender colourless needles of apatite traversing both the groundmass felspar and the green interstitial chlorite. In a weathered specimen of this rock the interstitial chlorite is yellow in colour, due to oxidation which no doubt accounts for the yellowish appearance of the outside surface of the rock in the hand specimen. There are also small granules of titanite.

In concluding the detailed descriptions it might be repeated that the augite from all the Permian lavas seen on the Five Islands is pale green in colour "characteristic of high alkalic content as opposed to the brownish augites of common basalts" (Ransome, 1898, p. 29).

Comparison with the other South Coast Permian Flows.

A selection of the original slides of the Blowhole, Bumbo, Cambewarra and Berkley Flows described by Card (Harper, 1915; Jaquet, Card and Harper, 1905–09) was kindly lent by the Mining Museum, and comparisons were made.

From the Bumbo Flow are described conspicuously porphyritic types occurring mainly in the Kiama district. Of more significance as regards Island IV is the fact that aphanitic types both basaltic and trachytic in appearance occur in the Jamberoo district. Bearing in mind the occurrence of the two aphanitic types on Island IV, this seemed suggestive. No slides, however, of the Jamberoo basaltic phase were available. It seems likely that this is a type in which the labradorite phenocrysts so typical of the Kiama quarry are smaller and less abundant. This feature has been mentioned by Card (Jaquet, Card and Harper, 1905–09, p. 9). Slides from the Kiama district (5774, 5423, and 5429) and two slides actually from the Kiama quarry were examined. These proved to be exactly the same as the basic latite from Island IV, excepting that some of the Kiama slides had larger and more abundant labradorite phenocrysts. Likewise examination of hand specimens and slides of the Jamberoo trachytic phase (5688, 5689, and 5692) showed them to be exactly the same as the acid latite from Island IV. No slides of zeolitized types or types with abundant cavities were noticed. In 5689 small green amphibole laths as in the Island IV hornfels no doubt represent a sedimentary inclusion. Unfortunately no details of the relation between these two phases of the Bumbo Flow are given.

As regards the other Permian Flows, the Dapto shows such distinctive characters that it could not possibly be confused with either of the Island IV phases. The Cambewarra, although to some extent chemically resembling the Bumbo acid latite, is distinguished from it by its orthophyric texture, the typical occurrence of apatite as stout markedly striated prisms, and by the universal presence of interstitial quartz. The Berkley, which microscopically does resemble the Bumbo acid latite, is of limited extent and thickness. It is a terrestrial flow intercalated with freshwater Upper Coal Measures filling a small drainage channel in the Upper Marine. The nearest occurrence is at Cobbler's Hill on the mainland, some 4¼ miles west of the Island, and there the base of the flow is 320 feet above sea-level. This together with the fact that here the sediments dip west as well as north makes correlation between the two difficult.

It is therefore concluded that Island IV represents an outlying remnant of the Bumbo Flow. It is 9 miles north of the most northerly outcrop of the main mass

on the southern shores of Lake Illawarra. There is no evidence to suggest that it was not once joined to the main mass which is most strongly developed in the Kiama-Jamberoo district. A similar instance is found 1½ miles north of the Shoalhaven River, where the most southerly outcrop of the Bumbo on Mount Coolangatta is 6 miles south of the most southerly outcrop of the main mass of the flow. However, since in the region between Wollongong and the Shoalhaven Harper (1915, p. 291) considers that there were two main centres of eruption—one at Kiama and one at Port Kembla—both east of the present coast line, it would be reasonable to suggest that eruption of the magma which consolidated to form the Bumbo Flow proceeded contemporaneously from both centres, that at Port Kembla being on a much smaller scale.

Chemically as well as mineralogically the Island IV acid latite resembles the trachytic phase of the Bumbo at Jamberoo.

	1	1a	2	3
SiO_2	58·21	0·970	55·19	52·42
Al_2O_3	15·45	0·151	16·18	18·05
Fe_2O_3	2·38	0·015	3·52	4·30
FeO	3·82	0·057	3·94	3·60
MgO	2·89	0·072	3·04	3·60
CaO	3·03	0·054	4·68	6·14
Na_2O	5·16[1]	0·083	5·09	3·75
K_2O	4·24	0·045	4·10	4·14
H_2O+	2·12		1·75	1·07
H_2O-	0·71		0·99	1·47
CO_2	0·14	0·003	0·28	0·04
TiO_2	0·88	0·011	0·89	1·16
P_2O_5	0·82	0·006	0·59	0·34
V_2O_5	—		0·03	0·05
SO_3	—		0·05	none
Cl	tr.[1]		0·02	tr.
NiO	0·12		none	0·03
CuO	—		0·01	0·05
MnO	0·22		0·18	0·28
BaO	—		0·07	0·11
	100·19		100·60	100·60
Specific gravity	2·70		2·80	2·72

[1] Allowance made for contamination by sea-water.

	1	2	3
Quartz	2·70		
Orthoclase	25·02	24·46	24·46
Albite	43·49	42·44	31·44
Anorthite	6·39	9·45	20·29
Diopside	1·79	8·25	6·32
Hypersthene	10·43		0·30
Olivine		4·61	4·78
Magnetite	3·48	5·10	6·26
Ilmenite	1·67	1·67	2·28
Apatite	1·86	1·35	0·62
Calcite	0·30		

1. DR 4235. Acid Latite. (Akerose, II, 5, (1)2, (3)4.) Island IV, Five Islands, Port Kembla, N.S.W. Analyst, R.O.C.

1a.—Molecular ratios for 1.

2.—Olivine Latite, aphanitic phase. (Akerose, II, 5, 2″, 4.) 3½ miles north of Jamberoo, N.S.W. Analyst, J. C. H. Mingaye. (Washington, 1917, p. 463; also Harper, 1915, and Jaquet, Card and Harper, 1905-09.)

3. Olivine Latite, phaneric phase. (Shoshonose, II, 5, ″3, 3″.) Average of several specimens, Bumbo Quarry, Kiama, N.S.W. Analyst, H. P. White. (Washington, 1917, p. 479; also Harper, 1915, and Jaquet, Card and Harper, 1905-09.)

In the N.S.W. Geological Survey publications (Harper, 1915; Jaquet, Card and Harper, 1905–09), analysis 2 falls into the sub-rang Monzonose, but in Washington's tables (1917) it is in Akerose. Although analysis 3 falls into Shoshonose in all the above-mentioned publications, there seems to have been some error in working out the norm in Washington's tables. Therefore, the norm has been recalculated, and it is this result that is appended under analysis 3. It does not differ greatly from Card's result.

DR 4235, the bluish grey acid latite of the lower flow, was selected for analysis after the first visit to Island IV, when only a cursory inspection had been made. Although this specimen is the only fresh type on Island IV containing interstitial quartz, it is small in amount and the rock differs only in a minor degree from the greenish grey acid latite DR 4237. The basic latite was not noticed until my last visit to the island, and time has not permitted an analysis to be made; therefore for purposes of comparison the analysis of the very similar type from the Bumbo Quarry is included.

The norm of analysis 1 gives a truer representation of the mode of this particular rock as seen today than do the norms of 2 and 3 because, while olivine appears in their norms, no fresh olivine is to be seen in thin section. However, now and then in the Bumbo rocks, both from Island IV and the mainland, can be seen automorphic masses of chlorite, presumably alterations of iddingsite after olivine. The analysed specimen coming from the lower flow where the most deuterically altered types are found, suggests that the interstitial quartz in it may have been deuterically introduced. It certainly has a higher silica percentage than its counterpart at Jamberoo, and since the norm contains free quartz, olivine is eliminated. However, the fact that there is mostly fresh augite in the Island IV rocks as well as interstitial chlorite, indicates that this is more likely to be an alteration of olivine, especially since the likelihood of the chlorite-filled cavities having been formed as steam holes is largely discounted. On the other hand, as mentioned by Browne (1925, p. 249) when dealing with the Prospect intrusion, some of the chlorite may be the normal crystallization product of the ferro-magnesian constituents.

In all these descriptions of Bumbo latite from Island IV and Jamberoo, the acid latite has been referred to as a fresh type to distinguish it from the zeolitized and devitrified types as well as types with abundant cavities. However, despite its fresh appearance in the hand specimen, the presence of completely albitized felspars showing to a lesser extent sericitization, kaolinization and chloritization stamps it as a rock that has suffered considerable deuteric alteration. The iron ore, both magnetite and hematite in the form of small dots, rods and dendritic shapes fringing the groundmass felspars in some of the acid latites, is of a later generation than the small squarish pieces scattered haphazardly throughout the groundmass. It may have been introduced during the period of late deuteric activity. In the face of all this alteration, the augite has remained fresh, as noted on Islands I and II. The basic latite on the other hand shows perfectly fresh felspars, although interstitial chlorite, probably in part an alteration of olivine, is present.

There is a strong possibility that the acid latite phase of the Bumbo Flow is a product of deuteric alteration of the basic phase. Until one becomes accustomed to the appearance of both types under the microscope, it is often difficult to distinguish them. Actually the main distinguishing feature is the clean, fresh appearance of the felspars and absence of orthoclase phenocrysts in the basic latite. The distinctive unoriented, sometimes markedly criss-cross texture of Johannsen and the presence of small fresh pieces of augite are identical features in both phases. The presence of interstitial chlorite is a common characteristic, as is the occurrence of apatite needles and titanite granules.

It is rather difficult to make a close examination of the relations between the acid and the basic phases on the Island. The amount of the basic latite is small, and it appears to be both underlain and overlain by the dark green acid latite on a vertical cliff section (see Fig. 2), which makes it rather difficult to determine the amount of gradation between the two, if any. Also before a strict chemical comparison could

be made by recalculation of analyses on some standard basis, an analysis of the basic latite would be required. However, a rough comparison of the acid latite analyses (1 and 2) with the basic latite analysis (No. 3) shows gains in silica and soda and losses in lime and alumina. Just where the lime of the basic latite has gone since it was replaced may be explained by the presence of large masses of dark brown calcite and frequent smaller masses of white calcite occurring in the highly altered types. The abundance of epistilbite in the highly altered parts of the lower flow accounts for the replaced alumina and some of the lime. Also in the formation of chlorite, whether by alteration of ferro-magnesian minerals or by other means, alumina would be used up. It is noteworthy, too, that sericite which, according to Browne (Browne and White, 1929, p. 320), accounts for the alumina in the altered type B of the Dapto Flow being greater than in the fresh, is not of much importance in the Island IV rocks where, as already stated, there is less alumina in the acid latite than in the basic latite.

The presence of fresh and albitized trachybasalt (types A and B) in the Dapto Flow has been mentioned. In addition there is the pink, heavily calcitized rock (type D) which in the Port Kembla Quarry attained a considerable thickness, as proved by a trial bore (Browne and White, 1929, p. 306). Also, according to Harper (1915, p. 301), towards the southern extremity of the Dapto Flow at Broughton Head, some 20 miles to the south-west of Port Kembla, the resinous fresh trachybasalt gives place to the type with creamy opaque felspar phenocrysts. Although these specimens have not been seen, they appear to be the albitized, sericitized type B seen at the Quarry and on the Islands. Thus it would seem that there is a good deal of deuterically altered material in the Dapto Flow.

Such a widespread incidence of deuteric effects as seen in both the Bumbo and the Dapto Flows cannot be dismissed as a purely local phenomenon. The solutions that have brought about the changes, though they have acted late in the cooling history of the rock, are none the less part of the magma, and there is no reason why the rock types produced should not be regarded as normal rocks and classified as such.

Devitrification.

The occurrence of a glassy phase of the groundmass described in some of the altered types from the lower flow, sharply changing to a cryptocrystalline groundmass, is of interest when considering the effects of deuteric solutions. Usually the change is ascribed to devitrification. Devitrified latites are described from the Bonanza Mining district, Colorado, by Burbank (1932, pp. 21–30). In all of these devitrified types albitized plagioclase and other deuteric minerals, such as chlorite, quartz, calcite and epidote, are abundant. On the other hand, in associated glassy latites no mention is made of any alteration. Similarly Spock (1928, p. 232), describes a series of trachy-andesites associated with rhyolite, obsidian, andesite and basalt from Colorado, which either show residual glass or else are completely devitrified. These contain amygdules of calcite and various forms of silica. Osborne (1925, p. 117) gives a thorough discussion of devitrification in connection with the occurrence of glassy and lithoidal andesites in the Carboniferous of the Clarencetown-Paterson district, N.S.W. The glassy andesites are quite fresh, but the lithoidal varieties show albitization, chloritization and kaolinization, due to deuteric processes. He considers that the change from a glassy to a lithoidal groundmass might have been brought about by the activity of late-magmatic solutions. The view has been expressed by Hadfield and Whiteside (1936, p. 47), when dealing with some devitrified English andesites, that "so-called devitrification really arises from a primary crystallisation of minute proportions". However, in these very andesites the activity of deuteric solutions is shown by sericitization, calcitization and chloritization of plagioclase phenocrysts, and the presence of calcite cavities which are considered to be a replacement of felspar in situ rather than due to infiltration. This latter is a further resemblance between these and the Five Islands rocks. All this weight of evidence points to the devitrification on Island IV being another sign of deuteric activity.

Nomenclature.

Card (Harper, 1915, p. 284) points out that all these Permian flows are closely related magmatically one with the other and also with the Milton monzonite, some 60 miles to the south. Since they are effusive representatives of a monzonite magma, he gives them the name latite, following Ransome (1898, pp. 59–69). He says, however, that the name has been applied with little regard to mineralogical and textural differences. Browne (Browne and White, 1929, p. 317) in naming the Dapto Flow trachybasalt has evidently also regarded the name latite as having a purely chemical significance.

The Bumbo acid latite chemically resembles some of Ransome's augite latites from the Sierra Nevada (1898, p. 58). Others among the augite latites resemble more the Bumbo basic latite except that silica is about four per cent. higher. These rocks differ texturally from both the phases of the Bumbo in having labradorite and augite phenocrysts with some fresh olivine set in a hyalopilitic groundmass.

Comparing them with the rocks described by Iddings from Yellowstone (1895, p. 933, and 1899, pp. 340, 347), the basic latite has the closest chemical affinity with the banakites and shoshonites. Actually the average analyses of both these types quoted by Daly (1914, p. 34) show close resemblance. The acid latite resembles the quartz banakites. Many of these Yellowstone rocks are holocrystalline and bear a close mineralogical and textural resemblance as well, as mentioned by Card (Jaquet, Card and Harper, 1905–09, p. 14) and Brown (1925, p. 462).

The devitrified latites from the Bonanza mining district, Colorado (Burbank), have a fairly close resemblance both chemically and mineralogically to the Bumbo acid latite excepting that they are lower in alkalis, higher in lime, and contain biotite.

Analyses 1 and 2 of the Bumbo acid type both strongly resemble an analysis of an Italian vulsinite (Washington, 1917, anal. 8, p. 358). Ransome (1898) gives nineteen analyses of rocks that he considers latites, including his Sierra Nevada types and Washington's Italian rocks. Daly (1914, p. 23) has brought Ransome's average latite analysis more up to date, and the Bumbo acid latite bears a very close chemical resemblance to it, excepting that alkalis are higher and lime is lower.

A perusal of Washington's tables (1917) shows that, of the numerous analyses that could be classed as latites, only three fall in a dopotassic sub-rang. Nineteen analyses fall in sodipotassic sub-rangs and ten, many of which are called trachyandesites, in a dosodic sub-rang. Nor are any latite analyses published since 1917, that have come under my notice, dominantly potassic.

The striking predominance of soda over potash in the Bumbo acid latite in conjunction with its other chemical characteristics invites comparison with a series of Cenozoic trachyandesites described from Japan, Korea and Manchuria by Tomita (1935). These constitute a member of an alkaline limburgite-comendite suite. An average of eleven trachyandesite analyses (Tomita, 1935, p. 262) shows a close resemblance to analyses 1 and 2. In this paper is quoted Daly's world average for trachyandesites up to 1933 (see p. 284). The Bumbo acid latite also resembles this very closely. Two analyses of trachyandesites from the Warrumbungles, N.S.W., are given by Jensen (1907, p. 616), in which soda has not the same marked predominance.

In the face of all this, however, the fact remains that Brown (1930, p. 692) has shown the South Coast of New South Wales to have been a monzonitic petrographical province during the late Permian. To quote from another of her papers (1933, p. 351): "During the Upper Marine stage there were vertical adjustments of the adjacent land mass without strong folding and these were accompanied by the deposition of tuffs and flows of latite in the Illawarra district, sill-like intrusions at Milton and by laccolithic intrusion at Mt. Dromedary. These intrusions were monzonitic in character. . . ." She has described latite (banakite) occurring as a marginal phase of the Milton monzonite (1925, p. 456) and also latite forming irregular hypabyssal intrusions in the vicinity of Tilba Tilba Lake, Mount Dromedary (1930, p. 674).

In view of these opinions expressed after much detailed work and following Card's investigations, the name latite will be retained for these Island IV rocks. On looking

at Daly's world average for andesite (1914, p. 26) and for trachyte (p. 21), I would suggest that if further distinction were required, the Bumbo basic phase might be called andesitic latite, and the acid phase, trachytic latite.

Summary.

Islands I, II, III and V consist entirely of Dapto-Saddleback trachybasalt, a Permian Flow. On Islands I and II the succession is the same as in the Port Kembla Quarry, where a co-magmatic type intrudes the normal trachybasalt and subsequent attack by alkali and carbonate-rich solutions has produced various altered types. On Island IV two flows of Bumbo latite are found. Both a basic and an acid latite occur, the latter including devitrified and zeolitized types. It was most likely formed by the deuteric alteration of the former by predominantly soda-rich solutions.

Acknowledgments.

I am much indebted to Dr. W. R. Browne of the University of Sydney and Mr. T. Hodge-Smith of this Museum for their helpful discussions with me. To the former and to Mr. H. F. Whitworth, Curator of the Mining Museum, my best thanks are due for the loan of slides. Thanks are also due to Dr. A. B. Edwards of the University of Melbourne, who examined the slides showing the ilmenite-magnetite intergrowths and confirmed my observations.

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EXPLANATION OF PLATE VII.

Fig. 1.—Deuterically altered Dapto trachybasalt (DR 4206) from Island I. A phenocryst of albitized plagioclase is completely replaced by prehnite. × 25.

Fig. 2.—Deuterically altered Dapto trachybasalt (DR 4200) from Island I. This crystal shows a structure which was originally due to an ex-solution intergrowth of ilmenite and magnetite. The magnetite has been entirely removed, its place being taken by colourless chlorite and the ilmenite laths have been replaced by leucoxene. Outside the border of this crystal, on the left and also at the bottom of the section, the irregularly shaped dark masses consist of carbonates and the light material of felspar. × 100.

Fig. 3.—Acid Bumbo latite (DR 4240) from Island IV. The phenocrysts consist of albitized plagioclase, the one on the right showing partial replacement by chlorite. The dark patches in the groundmass consist of magnetite and interstitial chlorite. × 25.

Fig. 4.—Devitrified Bumbo latite (DR 4236) from Island IV. The central mass of chlorite preserves some trace of crystal outline. The outer rim consists of fibrous chlorite and the centre of tiny rosetted masses of chlorite. Microphenocrysts of albitized plagioclase stand out in a cryptocrystalline, devitrified groundmass. The two light coloured, roughly circular masses in the south-west quadrant are holes in the section. × 25.

Fig. 5.—Acid Bumbo latite (DR 4235) from Island IV. Two generations of magnetite can be seen. The earlier appears as irregularly shaped fragments and the later as a border on some of the laths of albitized plagioclase. × 100.

Fig. 6.—Basic Bumbo latite (DR 5870) from Island IV. All the felspar consists of fresh labradorite. Small dark patches in the phenocrysts are replacements by chlorite. Dark patches in the groundmass consist of magnetite and interstitial chlorite. × 25.

All of the above were taken in ordinary light.

Photographs by G. C. Clutton.

ON A NEW SPECIES OF *ANNULARIA* FROM NEW SOUTH WALES.

By A. B. Walkom, D.Sc.,
The Australian Museum, Sydney.

(Plate viii.)

Annularia Ivini, n. sp.

Stem slender, articulate; leaf-whorls and stem approximately in the same plane; whorls consisting of about thirty leaves, each leaf being joined to the neighbouring ones for half or more of its length. Leaves narrow, wedge-shaped and straight, greatest width near apex, which is obtusely rounded and prolonged into a mucro; traversed by a single prominent vein.

In the specimen there are remains of several leaf-whorls, two of which (Pl. viii, fig. 1) are adjacent whorls, with portion of the stem joining them preserved. This stem is about 1·5 mm. broad and the internode is about 2·5 cm. in length. The leaf whorl forms an almost continuous lamina, roughly circular in outline, adjacent whorls overlapping slightly; the leaves are joined for a little more than half their length, and are quite close together for the remainder. There are about thirty leaves in a whorl, the individual leaf being narrow, wedge-shaped and straight, about 15 mm. long and about 2 mm. wide at the widest part, which is some 2 mm. from the apex. Each leaf has a distinct midrib which shows as a very fine projecting line in the specimen. This fine line is usually in the middle of a narrow dark band some quarter of a millimetre wide, often widening slightly towards the apex of the leaf. In the few cases in which the apex of the leaf is preserved there is distinct indication of its prolongation as a mucro (Pl. viii, fig. 2), as in the specimens figured by Walton (1936, pls. 31, 32). There are a number of irregular markings diverging from the midrib (Pl. viii, figs. 3, 4), which possibly represent the markings on the leaf surface mentioned by Halle (1928, p. 239, pl. i, fig. 9) as being present on the adaxial side of leaves of *Annularia sphenophylloides*—the side of the leaf which, he suggested, faced upwards. Halle regarded these as representing hairs on the leaf surface, but Walton (1936, p. 231) considers them to be due to the presence of a "system of elongated darker structures of cellular dimensions" in the substance of the lamina. The appearance of the leaf impression in our specimen is very like that figured by Walton for *Annularia Jongmansi* (1936, pl. 31, figs. 12, 13).

The leaf whorl appears to be complete; there does not seem to be any gap either apically or basally. There is no marked difference in the lengths of leaves in a single whorl such as occurs in some species of *Annularia*, and which is characteristic of *Lobatannularia*.

The equality in length of the leaves and their linear character, and the absence of gaps in the whorl clearly differentiate the specimen from the genus *Lobatannularia* Kawasaki, and it seems reasonable to place it in *Annularia*. In general appearance and in size and disposition of the leaves it resembles *A. stellata*, but the fact that the leaves are joined for the greater part of their length in the portions of all the (five) whorls preserved, together with the appearance caused by the dark cell contents in the lamina, is perhaps sufficient to justify its separation as a distinct species.

Locality: Near the northern end of the Burning Mountain, about half a mile from Murulla Siding, which is 211 miles from Sydney by rail.

Horizon: Permian: Greta Coal Measures.

Type: Specimen No. F.39534 in the collection of the Australian Museum, Sydney. Collected by Mr. C. J. Ivin of Murrurundi, after whom the species is named.

I am indebted to Mr. C. A. Süssmilch for the opportunity of examining this interesting specimen.

Our specimen is clearly distinct from the plant described and figured by Etheridge (1895) as allied to *Phyllotheca* and *Cingularia*, which was later described by Arber (1905, p. 26) as *Phyllotheca Etheridgei*.

The specimen consists of a series of impressions of leaf whorls, preserved in a fine-grained, light coloured mudstone. Associated with these there are leaf fragments of *Glossopteris* (*G. Browniana* type) and articulate stem fragments (? *Phyllotheca australis*).

The only specimen previously described from Australia which at all resembles the present one is that described as *Annularia stellata* (?) from near Dunedoo, N.S.W. (Walkom, 1916). This shows distinct inequality in the lengths of leaves in a whorl, the leaves are separate for practically the whole of their length and are somewhat falcate in shape, being curved towards the apex of the shoot. Kawasaki (1927, p. 13) suggests that this belongs to his genus *Lobatannularia*, a suggestion with which we may agree. He refers it to his *L. inequifolia*, but perhaps it agrees better with Halle's (1927, p. 28) species *sinensis*, description of which was published very shortly after the appearance of Kawasaki's paper.

Whitehouse (1933, p. 38) has mentioned the occurrence of *Lobatannularia* in Queensland, but no description or illustration was published.

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EXPLANATION OF PLATE VIII.

Annularia Ivini, n. sp.

Fig. 1.—Specimen showing two adjacent leaf whorls, and portion of another. Approx. natural size.

Fig. 2.—Lower whorl of Figure 1, showing tendency to prolongation of leaves as a mucro. Approx. natural size.

Figs. 3, 4.—Portions of whorls showing the markings diverging from midribs of leaves. Figure 3, × 5·5; Figure 4, × 6.

All figures from specimen F.39534, Australian Museum Coll.

Figures 1, 3, 4 from photographs by G. C. Clutton.

THE CRANIAL ROOF OF *DIPNORHYNCHUS SUSSMILCHI* (ETH. FIL.).

By E. Sherbon Hills,
University of Melbourne.

(Plate ix and Figures 1–6.)

Introduction.

In 1933, the writer published a description of the cranial roofing-bones of *Dipnorhynchus sussmilchi* (Eth. fil.), based on an examination of the external features of the type and only specimen, which is preserved in the Australian Museum, Sydney (Reg. No. F.10813). This dipnoan skull was discovered by Mr. C. A. Süssmilch in the Middle Devonian limestones of Taemas, New South Wales, and was originally described as (?) *Ganorhynchus sussmilchi* by R. Etheridge, Jnr., in 1906. In 1927, Jaekel erected the new genus *Dipnorhynchus* for the specimen, the name being accompanied by an unlabelled original figure, but no written description. In view of the fact that the genus *Ganorhynchus* Traquair is not capable of precise definition and is applicable only to cosmine-covered dipnoan snouts (see Traquair, 1873; Newberry, 1889; Dutertre, 1929; Gross, 1933, 1937), it is undoubtedly preferable to designate the excellently preserved skull from Taemas as a new genus, the name *Dipnorhynchus* Jaekel being here regarded as valid (see also remarks in Hills, 1933, pp. 634–5).

Since the appearance of my earlier paper on *Dipnorhynchus* there has been much discussion about the homologies and nomenclature of the cranial roofing-bones in Devonian fishes, in the course of which the situation of the sensory canals of the lateral line system of the head has assumed considerable significance. As all statements in my previous description were based on examination of the external features only, no dissection having been attempted for fear of damaging the specimen, it was not possible to compare *Dipnorhynchus* in any detail with other dipnoans. The importance of the specimen in relation to the comparative anatomy of the group was, however, obvious, and it was therefore decided to make a partial dissection of the skull in order, if possible, to trace the sensory canals. My thanks are due to Dr. Charles Anderson, former Director of the Australian Museum, for kindly authorizing preparation of the specimen, and to the present Director, Dr. A. B. Walkom, for permission to complete the examination.

The cavity of the skull is filled with massive limestone that adheres strongly to the bones, and it was not until the specimen of *Coccosteus* from the Middle Devonian limestones of Buchan, Victoria, had been studied (Hills, 1936) that a satisfactory and fairly rapid technique for the dissection of such material was developed. Serial sectioning was not favoured for either specimen because each is unique of its kind, and it was desired to preserve them intact as far as possible. In *Dipnorhynchus* the sensory canals were traced by excavating the covering bone and the calcite infilling the canals with dental probes and fine needles, cleaning being carried out by the application of hydrochloric acid with a camel-hair brush. After this treatment the specimen was not suitable for photographic representation, but Figure 1 shows the structures actually observable on the left side of the skull, without any attempt at reconstruction. A few significant details were also obtained from the right side, particularly along the exposed edges of the bones.

Geological Horizon of Dipnorhynchus.

A recent study by Dr. Dorothy Hill (1941) of the rugose coral fauna of the Middle Devonian limestones in the neighbourhood of the Murrumbidgee and Goodradigbee Rivers, from which *Dipnorhynchus* was obtained, indicates that the age of the beds is Couvinian (lower Middle Devonian). I am indebted to Dr. Ida Brown for provisional confirmation of the field evidence that *Dipnorhynchus* was obtained from beds belonging to the Murrumbidgee Series, discussed by Dr. Hill in the above-mentioned paper.

The Sensory Canals of the Head.

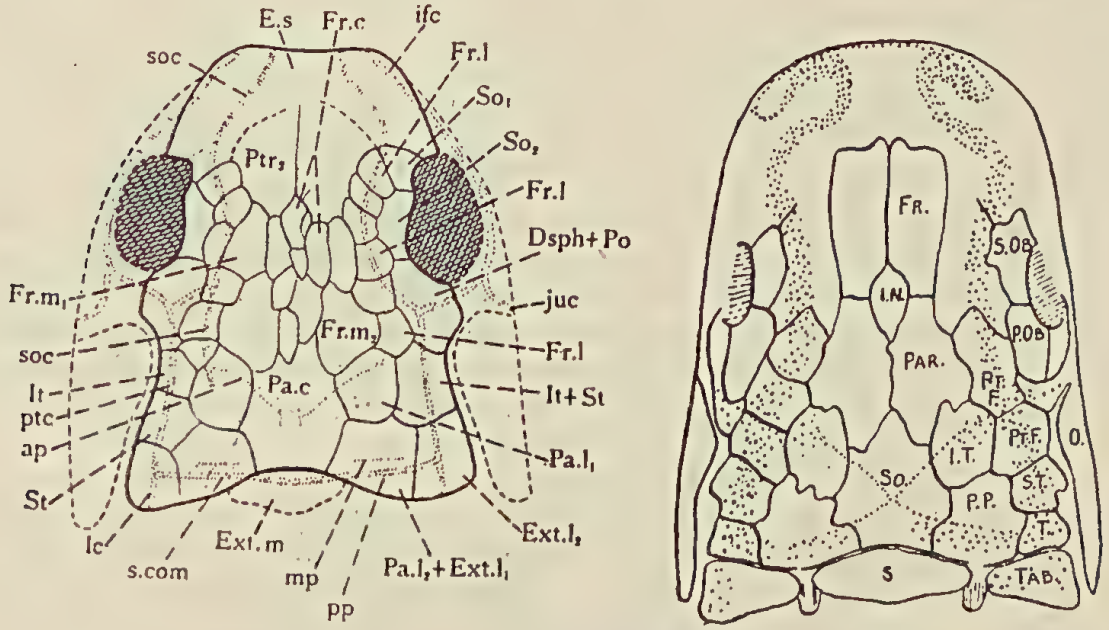
The sensory canals of the lateral line system of the head of *Dipnorhynchus* are represented in Figures 1, 5, and 6. The canals lie within the dermal bones, being connected with the exterior by tubules leading to superficial pores.

Fig. 1.—Outlines of the bones on the left side of the skull of *Dipnorhynchus sussmilchi*, showing the sensory canals and tubules as revealed by dissection. Drawn from a photograph taken normal to the side of the skull, to facilitate comparison with flattened dipnoan crania.

On the left side, the more mesially situated canal (o.b., Fig. 6) emerges posteriorly through the fractured edge of the cranial roof and is therefore incompletely represented, but on the right side the specimen extends further back, and the corresponding canal is seen to rise towards the outer surface of the bone, terminating within it. The anterior continuation of this canal is undoubtedly the supra-orbital canal (s.o.c.). As it passes forward, the supra-orbital canal, where dissected on the left side, gradually becomes more deeply embedded in the bone, and finally, as Säve-Söderbergh (1933) found in *Osteolepis*, it passes beneath the bone. The approximate course of the canal more anteriorly is, however, clearly indicated by the tracts of superficial pores on the snout (see Fig. 5, and Pl. ix, fig. 2). Its probable course is indicated in Figure 6. There are also, on the antero-lateral parts of the snout, tracts of pores that indicate the course of the anterior parts of the infra-orbital canals (i.f.c.).

Lateral to the canals above referred to, there is, in that portion of the skull behind the eyes, a second pair of canals, traversing the bones adjacent to those in which the more median canals lie, but turning sharply downwards behind the eye. In this latter region the data from the left side were somewhat incomplete, but corroborative detail was obtained from the right. On the right side, this lateral canal emerges posteriorly through the edge of a bone that is preserved intact, so that this canal must be the continuation of the main lateral line of the body. The only indication of the presence

of an occipital cross-commissure is a short and indistinct remnant on the fractured posterior edge of bone 8, Figure 5. Moreover, there is no indication of any branches linking the lateral and mesial canals on either side, such as are present in *Dipterus platycephalus* and *D. valenciennesi* (Figs. 2a and 3a).



a b

Fig. 2.—A. *Dipterus platycephalus*, after Stensiö. Dsph. + Po., fused dermo-sphenotic and post-orbital; E.s., ethmoidal shield; Ext. l., lateral extrascapular; Ext. m., median extrascapular; Fr. c., Fr. l., Fr. m., central, lateral, and median frontals; It., inter-temporal; Pa. c., Pa. l., central and lateral parietals; Ptr., post-rostral; So., supra-orbital; St., supra-temporal; ap., anterior pit line; ifc., infra-orbital canal; juc., jugal canal; lc., main lateral line canal; mp., middle pit line; pp., posterior pit line; s. com., occipital commissure; soc., supra-orbital canal.

B. *Dipterus platycephalus*, after Goodrich. Fr., frontal; I.N., inter-nasal; I.T., inter-temporal; O., operculum; Par., parietal; P.P., post-parietal; Pt.F., post-frontal; S., "median post-occipital"; So., dermo-supra-occipital; S.Ob., supra-orbital; S.T., supra-temporal; T., pretabular; Tab., tabular.

The sensory canals pass through the growth centres of the individual bones. In the neighbourhood of each growth centre, groups of tubules arise from the canals, and lead to pores on the exterior (see Fig. 1). This condition is similar to that in the only other dipnoan for which the tubules have been described, viz. *Fleurantia* (see Graham-Smith and Westoll, 1937), but is quite distinct from the arrangement in *Osteolepis* (see Säve-Söderbergh, 1933), in which the tubules, although showing a distinct organization in groups, arise at fairly regular intervals along the canals, within each group. As in *Fleurantia*, some of the tubules in *Dipnorhynchus* are long, others short; some are simple, others bifurcate; some, like the ribs of a fan, radiate from a centre, while others are spaced out along the canal near the growth centre of a bone.

Only one line of pit organs is discernible on the skull, this being situated on bone 16 (Fig. 5; Pl. ix, fig. 1).

On the snout, the course of the sensory canals can be judged only from the arrangement of the superficial pores. These are in clearly defined tracts, and it is possible to recognize that, on the antero-ventral surface of the snout, the two mesially situated canals are connected by a short commissure, the region enclosed within the canals and commissure being slightly raised above the general surface and forming the rostral prominence (7, Fig. 5).

The anterior parts of the infra-orbital canals are represented by pores on the antero-lateral margins of the snout on either side. There is, however, a well-defined gap between these pores and those belonging to the mesial canals, so that the

infra-orbital canals probably terminate anteriorly without making an anterior commissure.

Nomenclature of the Sensory Canals.

The nomenclature of the sensory canal system in fishes is based on topography and innervation. Säve-Söderbergh (1933, pp. 5–10) has made a detailed analysis of the canal system, and proposed a consistent nomenclature which it seems advisable to use as far as possible in the interpretation of *Dipnorhynchus*. The innervation of the various canals in *Dipnorhynchus* cannot, of course, be studied, and one is forced to rely on purely topographic data in the homologization of the canals with those of other fishes. Two illustrations of *Dipterus* are particularly useful for comparative purposes, and are reproduced in Figures 2a and 3a. These are of *D. platycephalus* by Stensiö (in Säve-Söderbergh, 1932, p. 96) and of *D. valenciennesi* by Westoll (in Graham-Smith and Westoll, 1937, pp. 244, 251). The general resemblance between the sensory canal systems in these two species and *Dipnorhynchus* is at once obvious. One may recognize in all three the supra-orbital canals. The plan of these canals is remarkably constant,

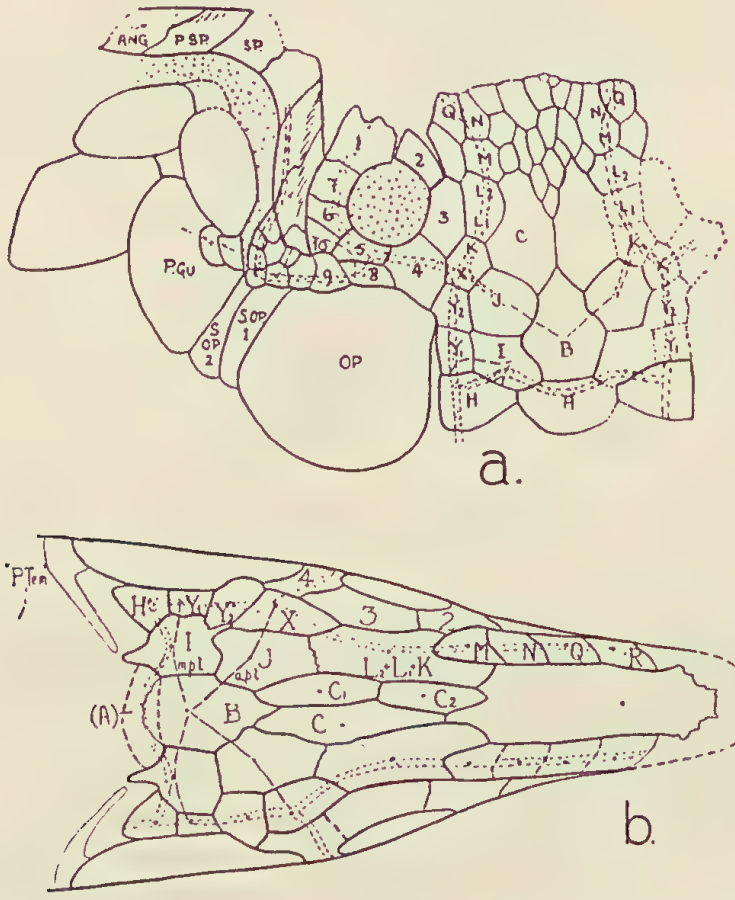


Fig. 3.—A. *Dipterus valenciennesi*, after Westoll. Lettering and numbering of cranial roofing bones based on an arbitrary system by Foster-Cooper.

B. *Fleurantia denticulata*, after Graham-Smith and Westoll. Lettering and numbering correspond with Fig. 3*a*.

so far as is known, among the Dipnoi. Not only in the above-mentioned illustrations of *Dipterus*, but also in Goodrich's figures of *D. platycephalus* and of *Epiceratodus forsteri* (see Figs. 2b and 4 herewith), also Foster-Cooper's illustration of *Protopterus* (1937, p. 234), the supra-orbital canals exhibit characteristic flexures. In all these forms there is a mesially convex flexure between the eyes, followed anteriorly by a laterally directed convexity, and then by a sweeping inward flexure that brings the canals quite close together. In *Epiceratodus* and *Protopterus* there is a short rostral commissure joining the two branches of the supra-orbital canal on the front of the snout in a similar manner to that in *Dipnorhynchus*. Illustrations of this region in other fossil dipnoans are not available for comparison, but there can, in view of the

above-mentioned topographic similarities, be no doubt about the identification of the supra-orbital canals in *Dipnorhynchus*. They are at least the anterior parts of the more mesially situated pair of canals. In *Dipterus* and *Dipnorhynchus*, however, these canals extend well back behind the orbits, and Westoll's figures of *Dipterus valenciennesi* indicate their posterior portions to be somewhat divergent from the course of the supra-orbital canals proper. Moy-Thomas remarks that the posterior branch represents the anterior pit-line developed in part as a canal, and the arrangement in *Dipterus valenciennesi* is not inconsistent with this view. The equivalent canals in *Dipterus platycephalus* and *Dipnorhynchus*, however, are clearly an integral part of the supra-orbital canal system. In *Dipterus platycephalus* the anterior pit-lines are divergent from the canals in question, and there is a short extension of the canals behind the contiguous ends of the pit-lines. I therefore believe that the anterior pit-lines and the canals are distinct structures. Although the canals are part of the supra-orbital canal system, as indicated by Stensiö, their length in the region behind the orbits in *Dipnorhynchus* suggests that they are probably differently innervated and should be distinguished from the supra-orbital canals. Owing to their apparently close connection with the anterior pit-lines, which in many dipnoans lie partly within the median unpaired bone that has been called the median occipital, they will be referred to as the occipital parts or branches of the supra-orbital canals.

With regard to the lateral pair of canals, it is clear that the part turning downwards behind the eyes is the vertical portion of the infra-orbital canal. The canal extending backwards from this vertical portion in *Dipnorhynchus* is clearly homologous with the similarly situated canal in *Dipterus*, and contains the otic canal in front, with the post-otic canal (so named by Säve-Söderbergh) behind. The latter is continued posteriorly as the main lateral line of the trunk.

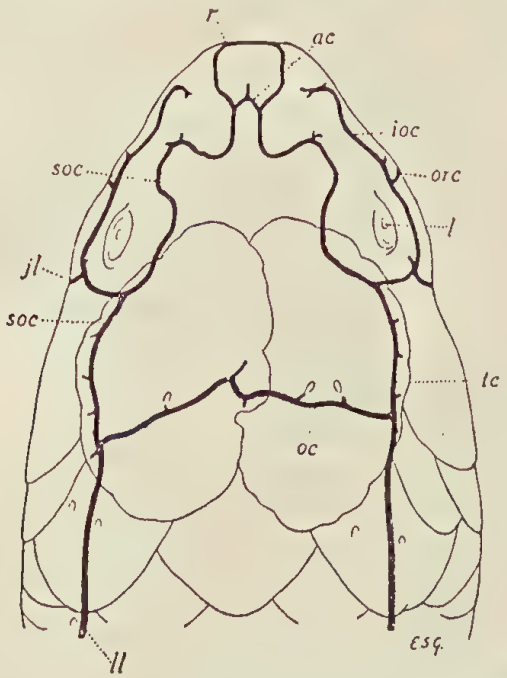


Fig. 4.—*Epiceratodus forsteri*, after Goodrich, showing the sensory canal system of the head. ac., anterior commissure; ioc., infra-orbital canal; jl., jugal canal; l., eye; l.l., main lateral line of the trunk; oc., occipital commissure; orc., oral canal; r., rostral commissure; soc., supra-orbital canal; tc., temporal canal.

Anteriorly, the infra-orbital canal traverses the lateral edges of the snout, but there is no evidence of any ethmoidal part (anterior commissure) linking the infra-orbital canals of the right and left sides. The arrangement of the pore tracts suggests rather that the horizontal portions of these canals terminate on either side of the rostral prominence, in a condition similar to that illustrated in *Epiceratodus* by Goodrich and in *Protopterus* by Foster-Cooper.

It may be remarked that Watson (1926) has illustrated the sensory canal system in the head of *D. valenciennesi* in a way differing considerably from that shown for the

same species by Jaekel (1929) and by Westoll (in Graham-Smith and Westoll, 1937). This illustration was the only one available to me when the previous account of *Dipnorhynchus* was written, and it appeared to agree with the canals in *Dipnorhynchus* in so far as these were deducible from the pore tracts. The infra-orbital, otic, and post-otic canals were not discovered until dissection was carried out. In the light of recent investigations of Palaeozoic Dipnoi and the present work on *Dipnorhynchus*, it seems preferable to omit Watson's figure from further discussions until the material on which it was based is re-examined.

Bone Homologies.

The concept originally proposed by Goodrich (1909), that there is a very close connection between the localization of dermal bones and the sensory canals of the head of primitive fishes, has now met with general acceptance (see especially Moy-Thomas, 1938; Romer, 1936; Säve-Söderbergh, 1933; Westoll, 1936, 1938), and is regarded as of major importance in the homologization of the cranial roofing bones. The general principles involved have been dealt with by Moy-Thomas, while Säve-Söderbergh and Westoll have both advocated radical revision of former ideas concerning the nomenclature and evolution of the dermal bones in primitive fishes. Final agreement has not yet been achieved on many points, the Dipnoi having proved particularly difficult to deal with, so much so that a scheme of lettering the dermal bones has been employed by some authors as a preliminary stage in the derivation of homologies with the Osteolepids on the one hand and the Tetrapods on the other. In order to avoid verbal confusion in this paper, the bone-nomenclature used in the description of *Dipnorhynchus* will be that of the Osteolepids, no attempt being made to apply Westoll's revised tetrapod-fish homologies as outlined in his papers of 1936 and 1940.

The species that most closely resembles *Dipnorhynchus* is *Dipterus platycephalus*. As will be seen by reference to Figures 2a and 5 herewith, the following points of comparison may be recognized: the lateral series of bones, traversed by the post-otic and otic canals and the vertical portion of the infra-orbital canal, is well defined. Stensiö's figure shows three bones in this series on the right, with four on the left. In *Dipnorhynchus* there are three bones preserved on the left, and four on the right, but the division of the central bone is by a longitudinal suture and not a transverse one as in *Dipterus platycephalus*. This subdivision in *Dipnorhynchus* is believed to be of no anatomical significance. It is clear that the anterior bone in this series, in which the sensory canal changes its course, is the homologue, wholly or in part, of the bone occupying a similar position in *Dipterus platycephalus*. This bone must contain a dermo-sphenotic element (see definition by Säve-Söderbergh, 1933, pp. 8–9), and may also, as indicated by Stensiö,[1] contain the post-orbital, since its posterior border extends well down at the back of the orbit. Comparison with *D. valenciennesi* also indicates that this bone is correctly identified (see Fig. 3a). The other bones normally represented in this series are, from front to back, the inter-temporal, supra-temporal, and lateral extra-scapular. Of these, the supra-temporal is usually connected with the lateral parts of the middle pit lines, as in *Osteolepis* and *Dipterus valenciennesi*. It is, therefore, probable that the bone on which the short pit line is situated in *Dipnorhynchus* is the supra-temporal. The bone on the left and the two bones on the right, anterior to the supra-temporal, are thus regarded as the inter-temporal. All the bones of this series so far identified in *Dipnorhynchus* are firmly attached together as integral parts of the skull roof. The lateral extra-scapulars, which normally follow behind the supra-temporals, are usually rather loosely attached to the skull. They contain the cephalic division of the main lateral line, and also the junction of this canal with the occipital cross-commissure (see Fig. 6). It is, therefore, necessary to add these bones to the skull of *Dipnorhynchus* in the restoration. This is also in accord with the fact that there is no indication of the cross-commissure in any more anterior bone of this series.

[1] I assume that the nomenclature of the bones, as well as their outlines, is due to Stensiö in the figure published by Säve-Söderbergh (1933), though this is not expressly stated.

Turning to the median bones, lying between the supra-orbital canals, it is clear that the most posterior bone preserved, which is an unpaired element, cannot be the median extra-scapular because it is an essential and firmly fixed part of the architecture of the skull roof, whereas the median extra-scapular is loosely connected with the remainder of the cranial roof, and contains the central portion of the occipital cross-commissure. A median extra-scapular has therefore been added in the reconstruction. In other dipnoans, the unpaired bone in front of the median extra-scapular is the so-called "median occipital" (to use Goodrich's non-committal term) and it lies between the posterior ends of the occipital branches of the supra-orbital canals, being normally

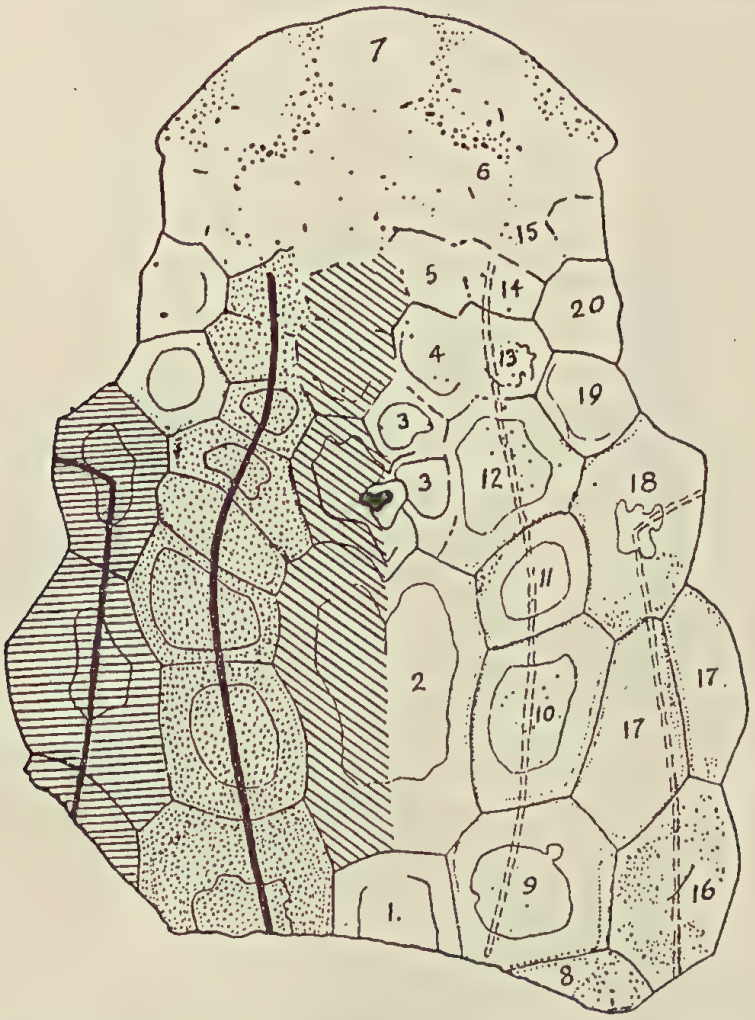


Fig. 5.—*Dipnorhynchus sussmilchi*, showing the outlines of the cranial roofing bones, the course of the sensory canals, and the pore tracts on the snout. On the left side the three longitudinal bone series are indicated by distinctive shading. On the right the bones are numbered to correspond with references in the text.

associated with the inner ends of the anterior pit lines. In *Dipnorhynchus* the anterior pit lines are not represented, but the bone in question does lie between the ends of the occipital branches of the supra-orbital canals, as in *Dipterus platycephalus* and *Dipterus valenciennesi*. In front of the "median occipital", there are in most Palaeozoic Dipnoi two bones, meeting in a longitudinal suture along the middle line. In *Dipnorhynchus* there can be no doubt that these bones are represented by a single element (2, Fig. 5), which, however, is subdivided along the middle line anteriorly. In Stensiö's figure of *Dipterus platycephalus* these two bones are probably represented by the large bones labelled Fr.m_2 (see Fig. 2a), which are separated by irregular small ossifications.

More anteriorly, paired bones junctioning along the middle line are recognizable in *Dipterus platycephalus* (after Goodrich; see Fig. 2b), *Dipterus valenciennesi* (after Jaekel), an unnamed species of *Dipterus* figured by Romer (1936), and in *Dipnorhynchus*. There is, however, in both genera, a notable tendency towards the distintegration of

the median paired bone series by the development of somewhat irregularly arranged small ossicles.

With regard to the homologies of these median paired bones, *Dipnorhynchus* presents one notable feature that is absent from other dipnoans, the presumed pineal foramen (p.f., Fig. 6). Romer (1936, p. 252) has taken the view that though the presence of the pineal body may be a stimulus to bone development, there is no evidence that the associated elements need necessarily be always the same, since the position of the pineal is dependent upon the position of the brain. In his interpretation of the skull of *Dipnorhynchus*, therefore, he sees no incongruity in identifying the bones penetrated by the pineal foramen as nasals. Westoll (1938, 1940), on the other hand, has advocated bone homologies for the Rhipidistra and for primitive tetrapods, in which the pineal foramen is always situated within the equivalents of the tetrapod parietals, regarded by him as the equivalents of the frontals in the old Rhipidistran (Osteolepid) terminology. There are, therefore, some grounds for assuming, as I originally did, that the bones penetrated by the pineal foramen in *Dipnorhynchus* are the homologues of the Osteolepid frontals, and much greater incongruity in calling them nasals, situated as they are behind the eyes, whereas the nasals are normally situated on the snout. In view of other evidence discussed below, however, it seems preferable to regard the pineal foramen as indicating in a general way only, the position of a region which contains the equivalents of the Osteolepid frontals.

The bones associated with the supra-orbital canals and their occipital branches in *Dipnorhynchus* form well-defined longitudinal series on either side of the skull. The regular progression of the numerous bones in these series is a unique feature of the skull, which is approached only by *Dipterus platycephalus* as figured by Stensiö. In other dipnoans the bones associated with the infra-orbital and supra-orbital canals are aligned in a smooth curve, but in *Dipnorhynchus* there is no link between these two canals, and the bone series associated with them must be regarded as distinct.

Anterior to the dermo-sphenotics, the bones normally connected with the supra-orbital canals on the snout and between the eyes in Rhipidistra are the nasals in front and the frontals behind them. Stensiö accordingly labels the small bones traversed by the supra-orbital canal in this region in *Dipterus platycephalus* "lateral frontals" (Fr.l., Fig. 2a), regarding the more centrally situated adjacent bones as "central and medial frontals". In other dipnoans, the supra-orbital canal in the region under discussion lies within one or more relatively large bones, and in *Fleurantia* Westoll and Graham-Smith have demonstrated that one such pair of large bones has developed by the fusion of three smaller elements on either side, represented by separate ossifications in *Dipterus valenciennesi*. They regard these composite bones as the equivalents of the Osteolepid frontals, the small ossifications situated between them in *Fleurantia* being regarded as not represented in the Osteolepids. Moy-Thomas (1937) regards the numerous bones penetrated anteriorly by the supra-orbital canal in *Dipterus* as "fronto-nasal ossifications", the centrally situated bones between them being "post-rostrals".

I believe that *Fleurantia* affords a definite clue to the real nature of the bones in the central region of the skull in Palaeozoic Dipnoi. The lateral line bone ($L_2 + L_1 + K$) in that genus (see Fig. 3b), which has been formed from the fusion of three smaller elements, appears to be developing into a transversely broader bone than the neighbouring elements of the supra-orbital canal series. In doing so, the roughly paired central elements (C, Cl, Fig. 3b) which probably correspond to somewhat larger bones in *Dipnorhynchus* (3, Fig. 5), have been rendered narrow and may readily be imagined as disappearing with further development of ($L_2 + L_1 + K$) as a unit. The evidence therefore suggests that the narrow median bones in *Fleurantia* are purely anamestic (i.e. filling in a space—term proposed by Westoll, 1936), and that ($L_2 + L_1 + K$) is the true homologue of the Osteolepid frontal. The extent and mode of development of the anamestic bones in any species may be correlated with three factors: firstly, that in primitive forms they are represented by two longitudinal bone series, contacting along the mid-dorsal line as advocated by

Romer and substantiated in *Dipnorhynchus*; secondly, that in the course of evolution the lateral line bones have tended to fuse and expand, assuming dominance in the skull roof as major structural elements at the expense of the anamestic bones; and, thirdly, that in forms at an intermediate stage of evolution the presence or absence of anamestic bones will be determined by the anatomical needs of the fish (broad, narrow, or average skull width) and the ability of the large organized lateral line bones to cover the area necessary. I therefore regard the numerous lateral line bones along the course of the supra-orbital canals in *Dipnorhynchus* as fronto-nasal ossifications, and the median, roughly paired elements as anamestic bones without strict homologues among the Osteolepids. Of these ossifications, I regard the nasals as being situated along the strong mesially concave flexure of the supra-orbital canal on the snout (6, Fig. 5), since, as formerly suggested (Hills, 1933, p. 639), the nasal capsules probably lay beneath this region. The more posterior bones (11–14, Fig. 5; Fr., Fig. 6) are regarded as frontals, though there may be some doubt as to the anterior and posterior limits of the frontal region.

On the above interpretation, the parietals should be situated in the posterior parts of the same bone series. In *Dipterus platycephalus*, according to Stensiö, the posterior ends of the occipital branches of the supra-orbital canals lie within the lateral parietals, the "median occipital" being regarded as the "central parietal", as it is also by Moy-Thomas (1937). It may be noted that in the Palaeoniscid fishes the supra-orbital canals also usually end in the parietals, and, as in *Dipnorhynchus*, the supra-orbital and infra-orbital canals in those fishes are not normally linked with each other. (The latter condition also obtains in the Acanthodii, according to Watson (1937).) Therefore, the bones labelled 9 in Figure 5 are regarded as parietals. If these bones are correctly identified, then those immediately anterior to them must also be regarded as parietals, on the following grounds: firstly, they lie too far back on the skull to be consistently regarded as frontals; secondly, as figured by Säve-Söderbergh (1932, p. 95), Stensiö has observed a specimen of *Eusthenopteron* in which there are two pairs of parietals separated by a transverse suture, so that it is probable that the normal parietals are developed from two primitive elements; thirdly, the parietals in *Osteolepis* extend over the same longitudinal range as the two bones in question in *Dipnorhynchus*, i.e., mesial to the supra-temporals and the inter-temporals.

Identification of the parietals in this way means that bone 8, Figure 5, corresponds to bone I (a lateral extra-scapular) in Westoll's figure of *Dipterus valenciennesi* (see Fig. 3a) and in part to the bone labelled $Pa.l_2 + Ext.l_1$ (fused lateral parietal and lateral extra-scapular) in *Dipterus platycephalus* (Fig. 2a). Moy-Thomas figures it as a lateral extra-scapular in *Dipterus* (1937, p. 311), and this is the interpretation adopted herein for *Dipnorhynchus*. It is, therefore, quite normal that a remnant of the occipital cross-commissure should occur within this bone in *Dipnorhynchus*, as mentioned above.

The unpaired "median occipital" (1, Fig. 5) has no homologue in the Osteolepids, nor has the bone 2, anterior to it. The name median occipital (or dermo-supra-occipital) used by Goodrich (1925, 1930) may therefore be retained for the posterior bone (1), so characteristic of the dipnoan cranial roof.

On the basis of the above arguments, the reconstruction and bone nomenclature shown in Figure 6 have been arrived at.

In adding a lateral margin to the skull in the reconstruction, and indicating the probable approximate position and outlines of the jugal, squamosal, and operculum, consideration has been given to the general form of the preserved portions, the geometry of the bones, the presumed course of the lateral line canals, and to the published reconstruction of *Dipterus valenciennesi* by Westoll (in Graham-Smith and Westoll, 1937).

It will be seen that *Dipnorhynchus*, though comparable in many respects with other dipnoans, especially with *Dipterus platycephalus* and *Dipterus valenciennesi*, differs from these and all others in several important regards. Among these are the great development of the occipital branches of the supra-orbital canals, the lack of a connection between these and the infra-orbital canals, the presence of a presumed

pineal foramen, and the large number of bones in the region posterior to a line joining the orbits. The dermal cranial bones in *Dipnorhynchus* are, more clearly than in any other dipnoan genus, arranged in longitudinal series, affording strong support for Romer's suggestion that such an arrangement was probably present in the ancestral dipnoan. The details of Romer's hypothetical bone series are not, however, borne out by *Dipnorhynchus*, nor are they by Stensiö's figure of *Dipterus platycephalus*. Thus between Romer's C series (associated with the supra-orbital and the main lateral line canals on the head) and the more mesially situated A and B series, there is, in both these forms, a further series associated with the occipital branches of the supra-orbital

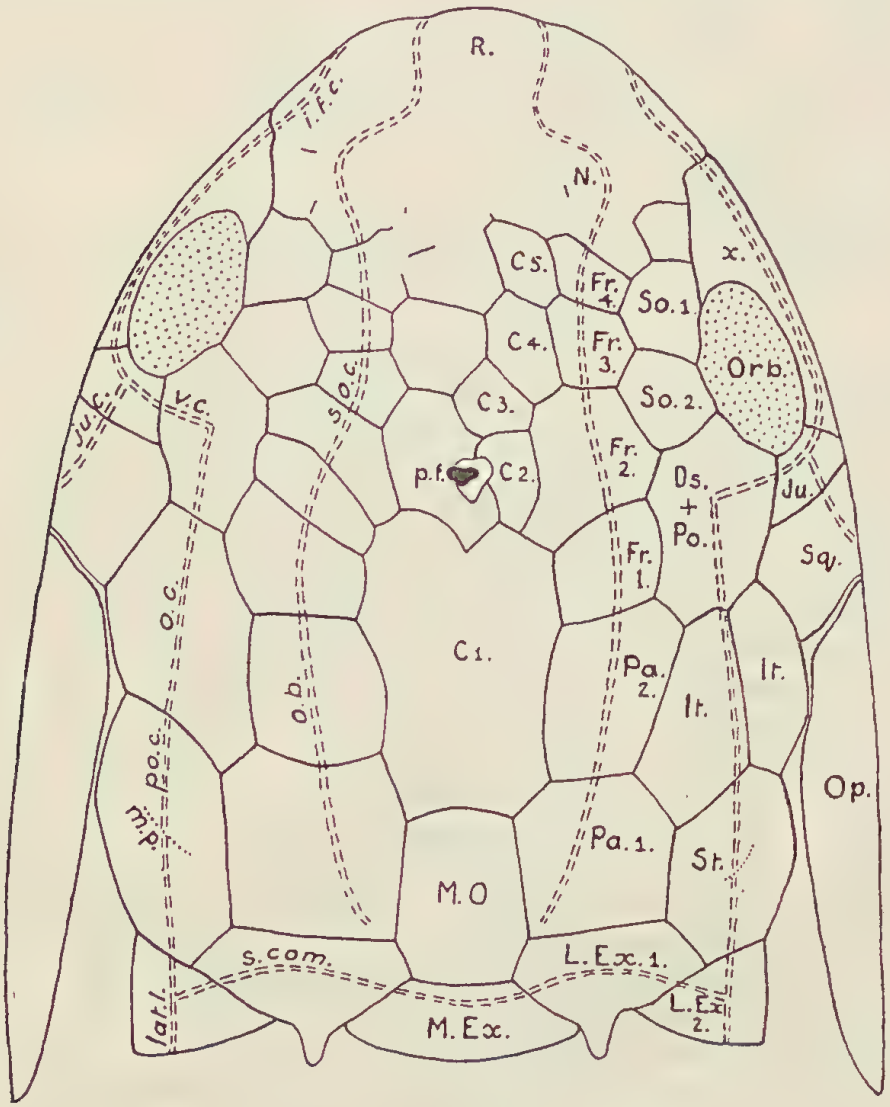


Fig. 6.—Reconstruction of the head of *Dipnorhynchus sussmilchi*, with the mid-dorsal line horizontal, based on a photograph. C 1, 2, 3, 4, 5, bones not represented in the Osteolepids; Ds. + Po., fused dermo-sphenotic and post-orbital; Fr. 1, 2, 3, 4, frontals; It., inter-temporal; Ju., jugal; L. Ex. 1, 2, lateral extra-scapulars; M. Ex., median extra-scapular; M.O., median occipital; N., nasal region; Orb., orbit; Op., operculum; Pa. 1, 2, parietals; R., rostral prominence; So. 1, 2, supra-orbitals; St., supra-temporal; Sq., squamosal; x., restored region, no subdivision attempted; ifc., infra-orbital canal; ju.c., jugal canal; lat. l., main lateral line; m.p., middle pit line; o.c., otic canal; o.b., occipital branch of the supra-orbital canal; p.f., pineal foramen; s. com., occipital commissure; s.o.c., supra-orbital canal; v.c., vertical portion of the infra-orbital canal.

canals. This point is clearly brought out in Romer's interpretation of *Dipnorhynchus* (1936, p. 243), where bone C4 is followed immediately (posteriorly) by B2, while in front of C3 is a bone of the D series (circum-orbital and cheek elements) which in actual fact is associated with the infra-orbital canal. It should be pointed out that Romer's interpretation was based on the author's earlier account of *Dipnorhynchus*, in which, although the cranial bones were accurately represented, the lateral line system was incompletely described, for reasons given above.

Conclusion.

Re-examination of the cranial roofing bones of *Dipnorhynchus sussmilchi* (Eth. fil.) has necessitated an entirely different interpretation of the skull from any formerly attempted. In conformity with its geological antiquity, the fish presents many primitive anatomical features which indicate that it is probably closer to the ancestral dipnoan than any other species yet discovered.

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EXPLANATION OF PLATE IX.

Dipnorhynchus sussmilchi (Eth. fil.).

Middle Devonian, Taemas, N.S.W.

1. Lateral view of the skull.
2. Vertical view, with the mid-dorsal line horizontal.

(Both × 1 approx.)

A REFERENCE LIST OF TYPES OF COLEOPTERA IN THE AUSTRALIAN MUSEUM.

By Keith C. McKeown.

CATALOGUE OF THE CERAMBYCIDAE (COLEOPTERA) OF AUSTRALIA.

By Keith C. McKeown.

These two papers are complete in manuscript. In view of the probability that they will not be printed for some time it is desired to record the fact that they are available, and that information concerning the species or the type specimens may be obtained by anyone working on the groups.—*Editor.*

LOWER ORDOVICIAN GRAPTOLITES IN NEW SOUTH WALES.

By R. A. Keble, F.G.S., and J. Hope Macpherson.

(Figure 1.)

The graptolites from Narrandera, New South Wales, in the collection of the Australian Museum, are particularly important as they represent the first undoubted evidence of Lower Ordovician rocks in New South Wales. The late W. S. Dun's statement (1930, p. 76) on examining them that "most of the Palaeozoics between Narrandera and Albury were Ordovician" becomes, therefore, a shrewd generalization.[1] The bed in which they occur is a highly cleaved, blue, andalusite slate, its alteration suggesting the close proximity of an intrusive igneous mass that may limit the

Figure 1.—*Tetragraptus quadribrachiatus* J. Hall. Approximately × 3.
Del. J.H.M.

possibility of finding other beds in the area. They are high in the Lower Ordovician, and, if part of a normal succession, are many thousands of feet above the older members of the Lower Ordovician on which the Victorian goldfields of Bendigo, Castlemaine and Daylesford are located.

Most of the Victorian goldfields occur along known tectonic lines. The Narrandera slates appear to be on the north-western extension of such a line passing through the Victorian goldfields of Harrietville, Bright and Chiltern. The reefs there are in unfossiliferous slates thought to be of Ordovician age. For that reason, it is desirable

[1] In an unpublished report on "Lower Ordovician Fossils near Narrandera, N.S.W.", dated 25th June, 1930, the late W. S. Dun referred to graptolite-bearing beds in Portions 56 and 57, Parish Corobimella, N.S.W., from which were obtained *Tetragraptus* and *Phyllograptus*, and also fragments of a crustacean, probably *Ceratiocaris*, and of an ophiuroid. He stated: "There appears to be little doubt that this series is an extension of the Victorian Lower Ordovician Belt and that it will be necessary to alter our Geological Map considerably."—Editor.

to ascertain the position of the Narrandera graptolite bed in regard to this tectonic line as it may lead to the discovery of payable reefs or leads.

The following forms are found at Narrandera:

Tetragraptus quadribrachiatus J. Hall (F.39697, Figure 1) (F.39696).

Glossograptus hincksii (Hopk.) (F.39697).

Glossograptus sp. (F.39694).

Climacograptus cf. *antiquus* Lapw. (F.39695).

Climacograptus sp. (F.39696) (F.39699).

They appear as a white film on the bedding-plane and are poorly preserved.

Tetragraptus quadribrachiatus (F.39696–7) agrees with Elles and Wood's description (1901–1918, pp. 57–8) except that the number of thecae to a given length is slightly less (7 in 10 mm.). It is the stout Lower Ordovician form and in nowise depauperated. The form identified as *Climacograptus* cf. *antiquus* Lapw. agrees fairly well with Elles and Wood's description of that form (1901–1918, pp. 199–200). The number of thecae to a given length is slightly less and the average width slightly greater. On the other hand, the thecae have that slight introversion of their apertural margins and the conspicuous elliptical excavations of *C. antiquus*. *Glossograptus hincksii* (Hopk.) (F.39697) agrees with Hopkinson's description of that form except that its width is, on the whole, greater. The polyparies are, however, not well preserved and the andalusite markings somewhat obscure the spines.

Climacograptus (F.39696, F.39699) is specifically unidentifiable. Beyond the fact that it reaches a maximum width of 2·3 mm., other characters are obscure.

Under Harris and Keble's subdivision (Harris and Keble, 1932) they would be placed in the Darriwil Series of the uppermost beds of the Lower Ordovician. Under the suggested subdivision of Harris and Thomas (Harris and Thomas, 1938) they would be regarded as Middle Ordovician.

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SOME FEATURES IN THE ANATOMY AND LATER DEVELOPMENT OF THE HEAD OF *DELPHINUS DELPHINUS* LINNÉ.

By H. Leighton Kesteven, D.Sc., M.D., Ch.M.,
Honorary Zoologist, The Australian Museum.

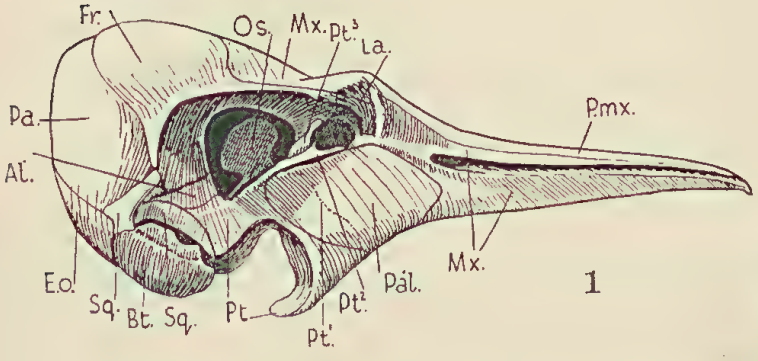
(Figures 1–29.)

Part I.—Osteology.

This part of the work is based on two foetal heads which I received from the New South Wales Fisheries Commission some years ago.

The larger of these was converted into a skull by careful dissection, and it has now been extensively disarticulated as the work proceeded. It measured seventy-eight millimetres from tip to occiput.

The smaller was decalcified and cut into serial sections along the sagittal plane after straining in alum carmine. This specimen measured fifty-two millimetres from



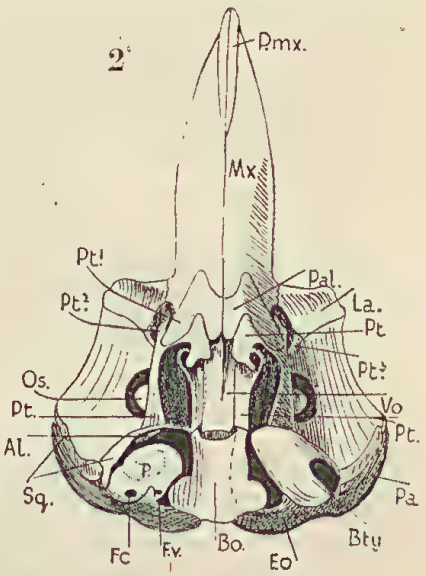


Fig. 1.—*Delphinus delphinus* Linné. The skull of a 78 mm. embryo, lateral view.
Fig. 2.—The same, ventral view.

Abbreviations used on illustrations to Part I.

A¹ & A², Accessory tympanic ossicle. Al., Alisphenoid. A.o., Ala orbitalis. Aq.coch., Aqueductus cochleae. Bo., Basioccipital. B.s., Basisphenoid. Bs.o., Basisphenoid ossific centre. Bt. & Bty., Basitympanic. C.n.l.d., Cartilage of the naso-lachrymal duct. E.o., Exoccipital. Fen.c., Fenestra cochleae. F.o., Fenestra ovale. Fr., Frontal. F.v., Fenestra vestibuli. I., Incus. La., Lachrymal. Le., Lateral ethmoidal plate of the vomer. L.t.a. & L.t.p., Lamina transversalis anterior and posterior. M., Malleus. Me., Mesethmoid. Mx., Maxilla. Na., Nasal. Os., Orbitosphenoid. Pa., Parietal. P., Pet. & Petr., Petrosal. Pl.e., Planum ethmoidale. P.mx., Premaxilla. Po., Postorbital process of the frontal. Ps., Presphenoid. Ps.a. & Ps.p., Anterior and posterior paraseptal cartilages. Ps.o., Presphenoidal ossific centre. Pt., Pterygoid.. Pt., Pterygoid and Palatine suture. Pt., Pterygoid, processus anterior. Pt., Pterygoid, processus anterior, lower limb. Pt., Pterygoid, processus anterior, upper limb. R., Rostrum. Sn., Septum nasi. Sq., Squamosal. St., Stapes. T.n., Tectum nasi. Ty., Tympanic bone. Vas., Vascular foramina. Vo., Vomer. VII, Facial canal.

tip to occiput. For this fine series of sections I am indebted to Professor C. W. Stump of the Department of Embryology and Histology, University of Sydney, and to him my sincere thanks are tendered.

In the larger specimen all the bones are completely ossified, whilst in the smaller much of the chondrocranium is still present. In fact, so much is this so that it has been possible to make comparisons between this chondrocranium and that of *Phocaena* as described by de Burlet (1913).

The chondrocranium resembles closely that of *Phocaena*; such differences as have been noted will be mentioned in the course of the description of the osseous skull.

THE SKULL.

Descriptive.

The general contours of the skull will be gathered from the drawings.

The Premaxillae (P.mx., Figures 1, 2 and 4) are elongated bones which fit in between the maxillae; superiorly they extend back the full length of the snout and bound the external nostril laterally. Inferiorly they appear as splints on either side of the midline, extending back somewhat less than half the length of the snout. The lateral face of the bone articulates with the maxilla. The lateral nasal process of the bone overlaps the frontal process of the maxilla, and its tip reaches the antero-lateral corner of the little nasal bone and lies upon the antero-medial corner of the frontal bone.

Upper and lower margins suture with the similar edges of the opposite bone. Between these edges the median face of the bones is concave and the anterior prolongation of the septum nasi lies between them.

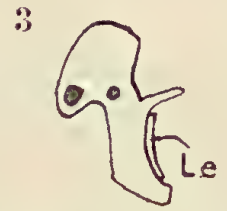


Fig. 3.—The maxilla, tranverse section just in front of the lachrymal bone.

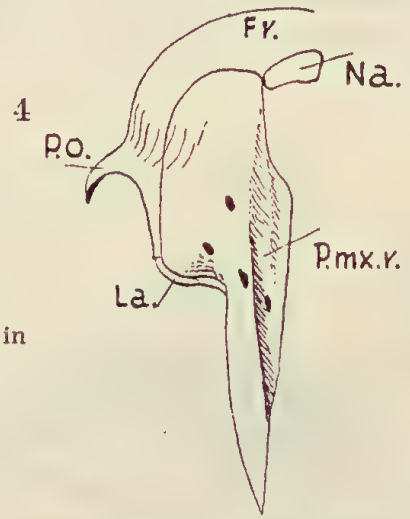


Fig. 4.—The same, dorsal view.

The Nasal Septum, fairly thick behind, where it is attached to the upturned face of the mesethmoid crest and the anterior superior edge of the vomer, becomes thinned as it extends forward and is attached above and below to the sutures between maxillae and premaxillae. This cartilaginous septum nasi has been termed the rostral cartilage by previous workers, but, inasmuch as its attachment behind to the mesethmoid crest and vomer and its situation between the two lateral ethmoid plates of the vomer definitely establish its identity as the septum nasi, it would appear a pity to hide that identity under another designation.

The Maxilla (Mx., 4*) presents for examination a body and an expanded frontal process. The cross section of the body just in front of the lachrymal bone is shown in Figure 3; for the rest the shape of the bone may be gathered from Figures 1, 2 and 4. The body of the bone is divided into upper, facial, and lower palatine portions by the very conspicuous dental sulcus (Figure 1). This sulcus is continued back by a canal which carries the posterior dental nerve from the pterygo-palatine fossa. A second branch of the maxillary division of the fifth nerve, apparently the combined anterior and median dental, enters the back of the maxilla by a canal placed more medially

* Numbers such as these refer to the structure as seen in the sagittal sections illustrated in Figures 24 and 25.

than the last and emerges into the dental sulcus about half-way along its length. A third canal from the same fossa enters the back of the bone and appears on the floor of the premaxillary recess (P.mx.r., Figure 4) behind the position of the transverse section; its opening in that recess is shown in Figure 4. The other two canals are cut across in the section. This third canal transmits a branch of the superior maxillary nerve.

The frontal process of the maxilla is a thin lamina which is spread over an extensive area of the anterior portion of the frontal bone (Figure 11) and covers most of the lachrymal. It bounds the external nostril laterally under the premaxilla, and there reaches the corner of the nasal bone. It is perforated by four foramina from the pterygo-palatine fossa, of which it forms the roof. These foramina transmit branches of the infraorbital nerve.

The sutures between the maxilla and the premaxilla, palatine, lachrymal and frontal bones are obvious in the drawings. Medially the lateral ethmoid plate of the vomer (Le.) is plastered to the face of the maxilla below the premaxillary recess. Posteriorly the body is hollowed out beneath the base of the frontal process to form the roof, anterior and posterior walls of the pterygo-palatine fossa, and the median wall makes sutural contact with the median limb of the anterior process of the pterygoid bone high up at the back of the fossa, immediately in front of the anterior margin of the frontal bone.

Posteriorly, between the ascending lamina of the palatine and the lateral ethmoid plate of the vomer, the maxilla forms the front wall of the nasal cavity and a median portion of its frontal process forms the roof of that same cavity.

The form and situation of the Palatine bone (Pal., 60) and its ascending lamina are clearly shown in the drawings, as also are all its sutures, with the exception of the common suture of both bones with the inferior margin of the vomer.

The Pterygoid (58) is a complex bone which calls for special illustration to cover adequately its form and relations (Figure 5). One may recognize, for descriptive purposes, a body, internal and external plates, a lamina dorsalis, and anterior, palatine, hamular and posterior processes.

The body is a relatively stout lamina which lies behind and is slightly overlapped by the posterior margin of the ascending lamina of the palatine bone. It is narrower, antero-posteriorly, above than below, and inferiorly turns into the horizontal plane and is continued backward a little way as the palatine process. The internal and external pterygoid plates are attached to the posterior margin of the body. Inferiorly these two plates are attached to the upper surface of the palatine process, and this, thus

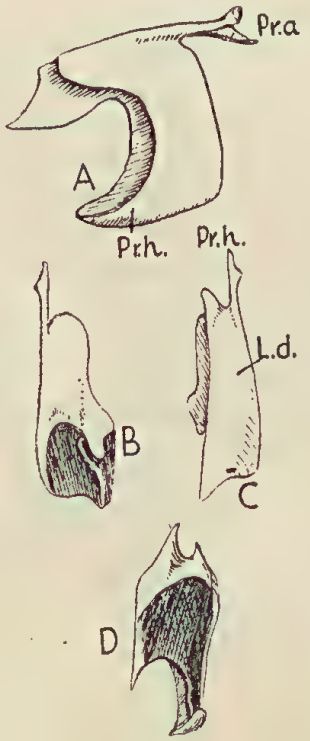


Fig. 5.—Pterygoid bone. A. lateral, B. ventral, C. dorsal, and D. posterior views.

strengthened, is continued backward and slightly downward, broadening somewhat, as the hamular process. Superiorly the plates are united by the lamina dorsalis, a horizontal lamina which lies beneath, and is sutured to, the basicranial alae. The lamina is narrow in front, where it underlies the base only of the ala orbitalis, and widens as it extends back so that it underlies practically the whole width of the alisphenoid ossification. The external plate does not extend so far posteriorly as the internal; it terminates where it sutures with the lower end of the pterygoid process of the squamosal bone. The lamina dorsalis is obliquely truncated at this point and the internal plate is continued back to suture with the lateral-down-turned edge of the basioccipital bone. The pterygoid plates, as they extend upward and backward from the hamular process and palatine lamina, arch inward, medially. This is more marked in the internal plate than in the external, and more pronounced posteriorly than in front. When the internal plate reaches the under side of the basicranial alae it turns mediad into the horizontal plane, adding to the width of the lamina dorsalis. Although the lamina dorsalis extends mediad of the dorsal edge of the internal plate anteriorly, and though that dorsal edge passes inward as it extends backward till it reaches the median margin of the dorsal lamina, the lamina itself is broader behind than in front because the dorsal edge of the external plate is here further from the midline.

The anterior process of the pterygoid (59) is a bifurcated continuation of the lamina dorsalis. The lower and lateral limb (Pt., 3) is a small pointed bar of bone which extends forward above the palatine bone, forming an incomplete floor to the hinder part of the pterygo-palatine fossa. The median limb is a shorter and stouter process which turns upward and mediad, and becomes applied along its superior margin to a ridge on the under side of the anterior margin of the frontal bone; the tip of the process makes contact with the maxilla on the inner wall of the pterygo-palatine fossa as already described. Behind the suture with the frontal bone the inner margin of the process sutures with the outer edge of the lateral ethmoid plate of the vomer (Figure 6, Pt. 4) in front of the orbitosphenoid bone. In this situation it forms the median boundary of the sphenoptic fissure in front of the orbitosphenoid and contributes a narrow area to the cranial floor.

Besides the sutural contacts already mentioned, the pterygoid bone is in contact with the vomer along the length of the median margin of the lamina dorsalis.

The Lachrymal (La.) is a roughly quadrilateral bone which is wedged in beneath the anterior portion of the frontal process of the maxilla in front of the frontal bone. It forms the outer part of the roof of the pterygo-palatine fossa and the fore part of the roof of the orbital fossa.

The Squamosal (Sq.) presents an irregularly pyramidal body which bears a small squamous lamina superiorly, a short stout laterally placed malar process and a long curved sickle-shaped pterygoid process in front. The body presents its longest face superiorly in the horizontal plane, and is coextensive with the lower margin of the parietal bone, to which it is sutured. The other two faces meet in a rounded angle, one looking anteriorly and a little ventrally, the other downward and a little posteriorly. The superior face of the bone is triangular and the malar process is attached along its outer edge. This process commences behind flush with the lateral margin of the exoccipital, by which it is slightly overlapped; as it extends forward it rises above the level of the body of the bone and is, by the body, carried out from the wall of the skull. It also projects below the antero-inferior face of the bone and extends forward and upward beyond the body of the bone. The pterygoid process (14) is a curved tapering anterior prolongation of the body which extends forward and mediad under the posterior margin of the alisphenoid bone, and then turns downward behind the posterior margin of the external plate of the pterygoid bone. Just where it turns downward away from the alisphenoid it carries the obliquely truncated posterior margin of the lamina dorsalis of the pterygoid bone with it.

The squamosal bone takes no part in the formation of the wall or floor of the cranial cavity, its squamous portion is quite small, and is applied to the outer aspect of the lower margin of the parietal above the body of the bone.

The Jugal is a little splint which extends between the postero-inferior corner of the supraorbital lamina of the frontal and the antero-superior corner of the malar process of the squamosal bone.

The Frontal (5 and 10) is an extensive bone, it forms the greater portion of the roof and anterior wall of the cranial cavity, and is quite thin except along the line of attachment of its supraorbital process. This latter is a relatively stout lamina which forms the roof of the orbital fossa, except for that small area supplied by the lachrymal. The anterior articulations of the frontal bone have already been detailed. Posteriorly the bone makes sutural contact with the interparietal and the parietal. Inferiorly it arches round the sphenoptic hiatus and behind this sutures with the anterior half of the outer margin of the alisphenoid bone.

The Interparietal is an irregular quadrilateral bone which is placed between the frontals anteriorly, the parietals laterally, and the exoccipital posteriorly.

The Parietals (Pa., 37) are a pair of narrow, curved, concave-convex bones wider below than above. They fit in between the frontal, interparietal, supraoccipital, exoccipital body of the squamosal and the posterior half of the lateral margin of the alisphenoid bone. So far are these bones curved round inferiorly that they share in the formation of the cranial floor lateral to the alisphenoid and the otic capsule. Behind the alisphenoid they lie lateral to the petrosal bone, but do not make contact therewith.

The Supraoccipital overlaps the hinder margin of the interparietal and on each side it sutures with the parietal above and the exoccipital below.

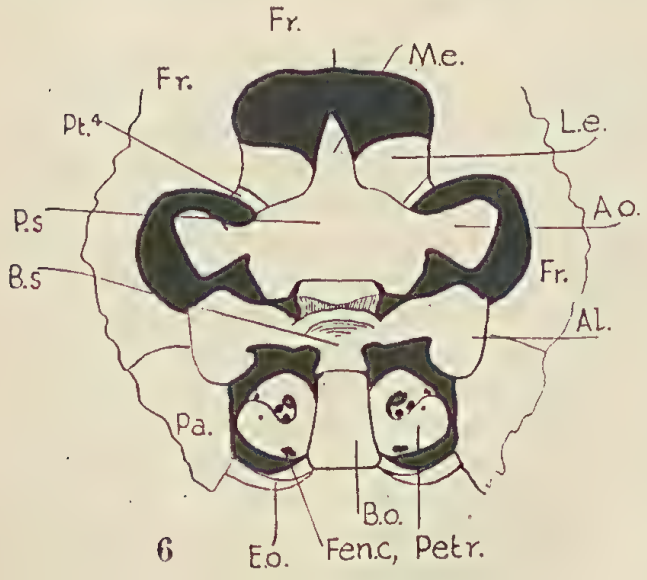
The Exoccipital (17) bone is sutured to the posterior face of the squamosal below, and above this to the hinder margin of the parietal. Above the foramen magnum it sutures with the supraoccipital and below with the basioccipital.

The Basioccipital (Figures 2 and 6, Bo.) presents a solid oblong body in the base of the cranial cavity and, on each side, a squamous process which extends downward and laterally beneath the canalicular portion of the petrous bone, but does not make contact with it, to suture with the inferior margin of the exoccipital bone.

The Basisphenoid (Figure 6, B.s., 55), in front of the basioccipital, is a little broader, but is neither as long nor as thick. The sella turcica on its dorsum is a shallow, relatively broad, depression. A carotid groove is impressed on the dorsum of the bone laterally and posteriorly at the point of attachment of the alisphenoid. The vomer is applied to its inferior surface.

The Presphenoid (Figure 6, P.s.) merges on either side into the orbitosphenoid and anteriorly into the ethmoid.

The form of Alisphenoid (Al., 15) and Orbitosphenoid (A.o. and Os.) is sufficiently shown in Figures 2 and 6, and they call for no further comment here.



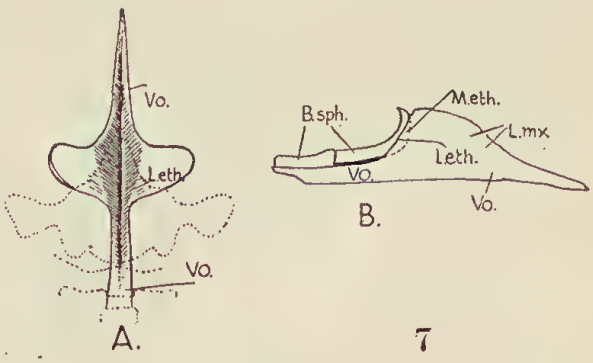
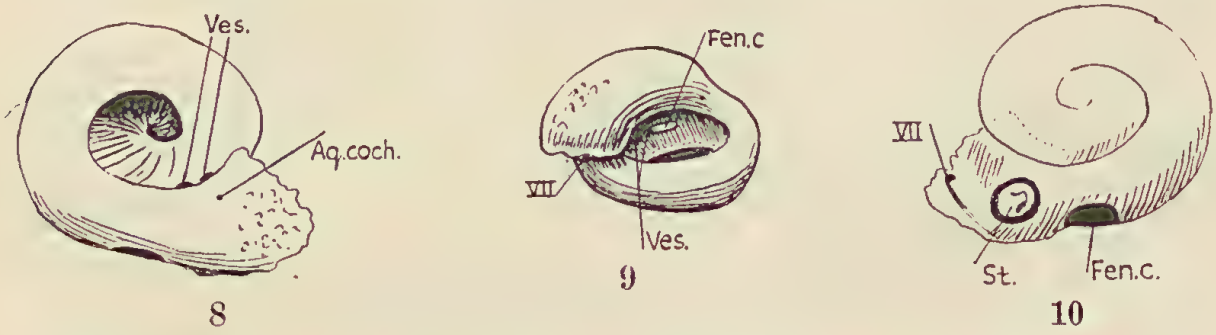


Fig. 6.—The cranial floor from above.

Fig. 7.—The Vomer. A. dorsal, and B. lateral views.

The Vomer (Figure 7) is an extensive bone which commences behind as a narrow flat plate applied to the under side of the basisphenoid. Beneath the presphenoid it becomes concave superiorly and keeled inferiorly; a little further forward it becomes V-shaped in cross section and then Y-shaped. The lower arm of the Y is fitted to the interpalatine suture. From the middle of the length of the presphenoid-mesethmoid ossification the limbs of the V get rapidly longer as the bone extends forward; they rise attached dorsally to the lateral edge of the forward bulging, upturned mesethmoid portion of the ossification. At the forward margin of the medial end of the orbitosphenoid bone the upper portion of the lateral wing of the vomer is reflected into the same plane as that bone, and its dorsal surface forms a small portion of the cranial floor in front of the orbitosphenoid and medial to the upper limb of the anterior process of the pterygoid bone. In Figure 7A, which depicts the vomer from above with the presphenoid-mesethmoid ossification and orbitosphenoid indicated in dotted lines over it, this lateral wing of the vomer is lettered L.eth. Forward of this point the two limbs of the Y rise a little higher still and become plastered to the inner face of the maxilla. At the posterior end of the intermaxillary suture the lower limb of the Y is dropped and the bone from here forward is once again V-shaped, the limbs of the V becoming shorter and shorter as the fore end of the bone is reached. The inferior margin of the vomer appears for a short distance between the maxillae on the palatine surface immediately behind the interpremaxillary suture. In Figure 7B the extensive limb of the bone applied to the medial face of the maxilla is lettered L.mx.

The resemblance of the Petrosal Bone to a discoid land shell with a dextral coil and a widely open umbilicus is very striking, and, continuing the simile, as it lies in position in the floor of the cranium the umbilicus is uppermost and the mouth of the shell on the outer, lateral, side and looking forward. By far the greater part of the bone is the cochlear portion; the vestibule and semicircular canals are lodged in the last quarter whorl of the shell. In my specimen the petrosal bone is not sutured to any bone, but is held in position by fibrous tissue only (Figure 2, P.)



8 9 10

Fig. 8.—The petrosal bone, dorsal view. Fig. 9.—The same, dorso-medial view.
Fig. 10.—The same, ventral view.

On looking into the open umbilicus (Figure 8) the first complete turn of the cochlear scala is found to be freely open, and this scala is seen to burrow into the vestibular portion of the bone and end blindly. Since this blind end is the commencement of the scala tympani, one should, perhaps, have said it commences here instead of ends blindly. Looking through the open commencement of the scala one can see the fenestra cochleae on its outer wall (Figure 9, Fen.c.). The inner wall of the vestibular portion of the bone is perforated by two canals, which lead right through the blind end of the vestibular scala and its outer wall to the vestibule which lies medial to and behind that blind end. Lateral to these two canals the bone is grooved just where the vestibular portion of the bone, the mouth of the shell as it were, is applied to the penultimate whorl of the cochlea. This groove may be traced out and round the bone; near the ventral surface it becomes converted into a canal for a short distance and is then continued on again as a groove lateral to the fenestra vestibuli. The groove lodges the facial nerve; it is in fact an incomplete aqueductus Fallopii, and the little spicule of bone which converts it into a canal for a short distance is all there is to represent the prefacial commissure at this stage of development. The widely open umbilicus is, of course, the internal auditory meatus.

Turning to the inferior surface of the bone (Figure 10), the fenestra vestibuli, neatly fitted by the circular base of the stapes, is an obvious feature.

On removing the stapes one opens into the vestibule, and a very complete opening it is, for one finds that one removed the whole of the floor of the recess when the stapes was removed. This recess is cup-shaped and in reading the description which follows it must be kept in mind that the depth of the recess is the roof, when it is correctly oriented. Immediately inside the vestibule on the anterior wall, but towards the median side thereof, a fairly large foramen opens into the vestibular scala near its tip. Laterally to this, a little higher, are two other foramina, the inner openings of the two foramina observed on the upper side of the bone. The one nearest the cochlear foramen transmits the branch of the vestibular nerve to the ampulla of the anterior vertical canal; the external aperture transmits as well cochlear twigs to the first portion of the ductus cochleae. The other foramen transmits the rest of the vestibular nerve. Opposite the cochlear foramen and a little higher in the vestibule there is a little recess which tends dorsad and laterally and ends in two tiny canals. The recess lodges the ampullae of the external and posterior vertical canals, which are those seen in its depth. The canal for the common limb of the two vertical canals opens into the vestibule high up on the antero-lateral wall. The recess for the ampulla of the anterior vertical canal and anterior end of the horizontal canal is in front of the last foramen slightly lower down. The aqueductus cochleae leaves the vestibule in the centre of the roof, and appears externally as shown in Figure 8.

The long axis of the vestibule, that is the line drawn through the centre of the stapes and on through the top of the roof, is oblique to both horizontal and sagittal planes of the skull, so that produced from above downward it passes forward and medially, whilst the ductus endolymphaticus and its aqueduct are at right angles to the horizontal plane.

The Stapes is a very simple little bone consisting of a discoid body and a short peg-like process. In the smaller head the stapes, like all the auditory ossicles, is cartilaginous, and the sections show the process to be a very small loop. It may be that in the larger head the process has been broken.

In the Incus (Figure 11) we have but half an "anvil", the pointed end and the foot of that side are missing. The short process of the incus is fitted to a groove on the under side of a spur which stands forward from the apex of the posterior process of the tympanic bone. In the smaller skull this process of the tympanic is continuous with the cartilaginous capsule. The long process turns inward and its apex lies immediately beneath the stapedial peg.

The Malleus (Figure 12) presents for examination a body, manubrium and two processes. The mass of the bone is roughly triangular, with the rounded apex below. The face depicted in Figure 12A looks backward and medially and has the fore end of the incus fitted to it by connective tissue. As viewed thus the bone appears as though

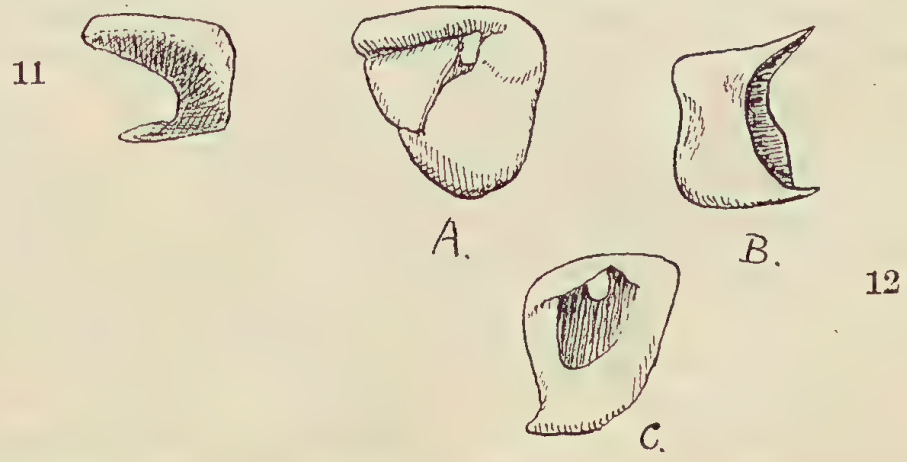


Fig. 11.—The Incus.
Fig. 12.—The Malleus. A. posteromedial, B. posterolateral, and C. anterolateral views.

formed by the folding of the lower and medial portion round the upper and lateral, for a groove which looks like a suture divides the one from the other. This groove commences near the middle of the median margin and extends downward and laterally, deepening as it does so, and terminates in a foramen situated low down near the ventral margin of the bone, above the base of origin of the squamous horizontal process. The Manubrium is that portion of the bone above and medial to the groove. The foramen transmits the chorda tympani nerve.

Viewed from the side (Figure 12B), the body of the bone is oblong, with the short margins above and below. The anterior face of the bone is excavated as shown (Figure 12C). There is a triangular lamina which projects forward and laterally from the upper margin of the body. A similar, but smaller, lamina projects back from the inferior angle. Two Accessory Auditory Ossicles are present (Figure 13, A^1 and A^2). Each is a little flat plate of bone attached to the antero-lateral margin of the body of the malleus, above the inferior process. The antero-inferior angle of the smaller, lower, ossicle is attached to the tip of the pterygoid process of the squamosal.

In Figure 13 the auditory ossicles have been drawn *in situ*, seen from below. The position of the tympanic membrane below the malleus is indicated by the dotted lines.

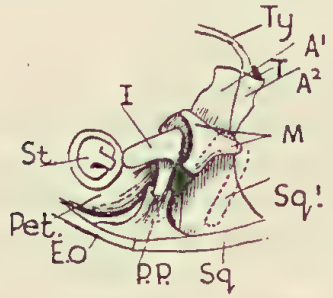


Fig. 13.—The tympanic ossicles in place, seen from below. The dotted line indicates the margin of the tympanic.

Fig. 14.—The Os tympani. A. lateral, and B. ventral views.

The Tympanic (Figure 14) is a spoon-shaped bone. The concavity is upward, and the long axis antero-posterior but slightly diagonally so that the fore end lies nearer the midline than the hind end. Four processes have to be described. The posterior arises from the full width of the posterior margin of the bone and turns abruptly upwards, and becomes wedged in in front of the sutures between the parietal, exoccipital and squamosal bones. At its apex the process bears a forwardly projecting spur, which is grooved on the under side for the reception of the incus. The posterior lateral process arises from the outer side of the bone. It is a thin, narrow bar of bone which, projecting back, becomes attached to the infero-lateral corner of the squamosal bone. The bay formed by this process and the margin of the main part of the bone is the annulus tympanicus, and it is filled in the fresh state by the tympanic membrane. The anterior-lateral process is a broader and much shorter lamina which extends upward from the lateral margin to gain attachment to the inferior margin of the smaller accessory auditory ossicle. The anterior process is a narrow prolongation of the bone which is attached to the tip of the pterygoid process of the squamosal bone along with the small accessory ossicle.

On comparing this young Odontocete skull with the young Mystacocete skulls described by Ridewood (1922), a general agreement is apparent, but there are observable differences in several places.

At the outset, one may express complete agreement with Ridewood's conclusion that the "alisphenoid bone of the whales . . . is but the ossified ala temporalis". There is no trace of any pterygoid wing.

The squamosal bone of our skull differs from that of the balaenoid skulls in not appearing in the cranial wall within, and also in the form of the falciform process. In those this process is flattened and bifid; in this it is rod-like and ends in a tapered point. This point certainly curves round the anterior margin of the periotic bone, but it also meets the pterygoid bone in this situation, forming, as it were, a strengthening bar to the under side of the posterior margin of the dorsal lamina of that bone. Ridewood (p. 259) states, on the authority of Beauregard, that the processus falciformis does not meet the pterygoid bone in the Odontocetes. In both my foetal skulls the conditions are as just described, but in an adult skull before me I find the pterygoid bone less extensive posteriorly, so that the two bones do not meet.

It should be mentioned here that in my foetal skulls the foramen through which the third division of the fifth nerve passes ventrally is confined to the dorsal lamina of the pterygoid bone; the pterygoid process of the squamosal bone takes no part in its formation. Seeing that this foramen is quite extra-cranial, it is hardly correct to designate it foramen ovale (*vide* Ridewood, p. 259).

The bifurcated anterior process of the pterygoid bone which I have described is not present in the pterygoid bone of the balaenoid forms (*vide* Ridewood, fig. 14c, p. 260).

The palatine process of the frontal bone which Ridewood figures (fig. 15, p. 263) is not present in the foetal dolphin skull. Above the posterior end of the pterygoid the outer end of the alisphenoid bone intervenes between it and the parietal and frontal above and the squamosal behind (see Figure 1).

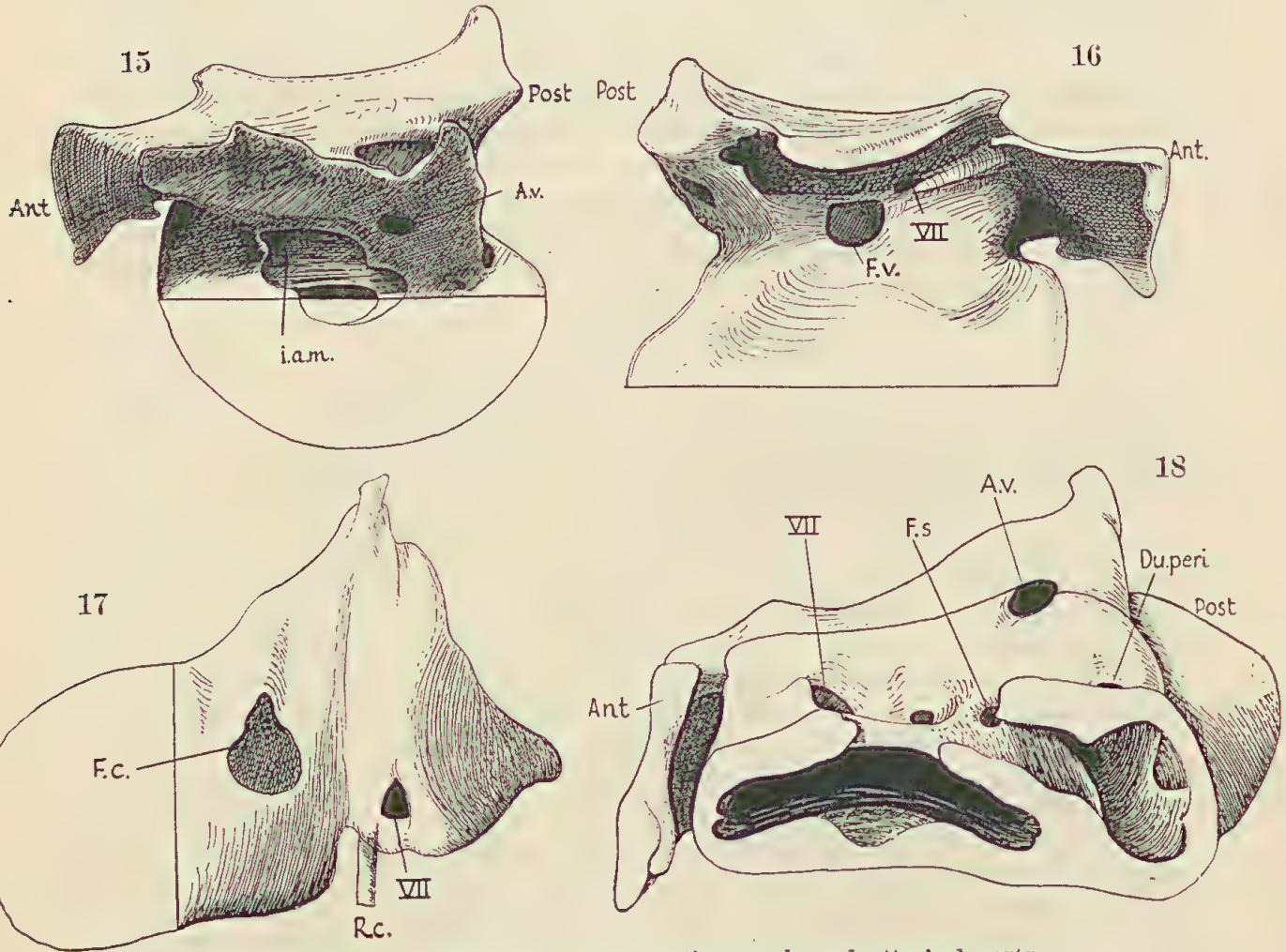
I hesitate to compare the tympanic bone of my little skull with those of the balaenoid forms, because it is an exceedingly fragile bone and so dissimilar that I have thought it well may have been mutilated in the process of disarticulation. It would, however, seem that, firstly, Ridewood's posterior pedicle (fig. 10, p. 241) corresponds with my posterior process, that his sigmoid process is my anterior lateral, and, secondly, his ossiculum accessorium is the anterior, and the facial process of the gonial is the posterior of the two accessory ossicles which I describe. If this be so, then that which I describe as the posterior lateral process of the tympanic bone is the "posterior conical process" which develops later in the balaenoid forms.

The cartilaginous otic capsule is of particular interest, and the better to study it a wax plate model has been made from the serial sections. This model comprises the whole of the vestibular and part of the cochlear portion, together with the attached tegmen tympani. In Figures 15, 16 and 17 the model is shown as seen from above, below and behind. In the first and last of these the part of the capsule not included in the model is indicated. The line along the unfinished edge of the model is the medial side of it and that face is in the sagittal plane, for it was from sagittal sections that the model was reconstructed. The dorsal line of the model corresponds to the horizontal plane along the long axis of the head. It will be observed that the model is thicker in front than behind; therefore, since the dorsal line is in the horizontal plane, the ventral slopes downwards from in front.

The marked difference between this cartilaginous capsule and the slightly older ossified capsule is due mainly to the attached massive tegmen tympani, but also, to a lesser degree, to an upstanding boss above the vestibular portion. The anterior portion of the tegmen later becomes ossified continuously with the os tympani, forming the anterior process thereof. The posterior portion, behind the sulcus incudis, becomes the posterior process of the same bone. Both portions lose their continuity with the capsule. The dorsal boss is, for the most part, absorbed later.

At no point is this otic capsule in continuity with the chondrocranium. The prefacial commissure is represented by the irregular mass of cartilage attached antero-laterally and dorsally to the pars cochlearis, and it is to this that the tegmen tympani is attached anteriorly. Confining the term tegmen to the horizontal portion of the tympanic processes, its attachment is continued along the dorso-lateral edge of the capsule and

it projects well beyond the capsule both in front and behind. Anteriorly the lateral projection of the tegmen is not marked, but increases towards the back of the capsule. Along its length the lateral edge of the tegmen carries a vertical flange. In front of the capsule this is in the transverse plane; beside the capsule the vertical flange is in the sagittal plane. Posteriorly the tegmen and its flange constitute the large irregular mass which Ridewood (1922) designated the crista parotica. The vertical flange ends posteriorly in a curved margin which rises towards the lateral margin of the fenestra vestibuli. To the outer side of it there is attached a stouter ridge which merges



Figs. 15-18.—A model of part of the otic capsule and attached parts.
15. Dorsal view. 16. Ventral view. 17. Posterior view.
18. Medial section.

superiorly into the contour of the capsule, but inferiorly curves up and backward forming a solid, low flange which overhangs the fenestra. The body of the malleus is fitted to these two curved margins. Near the centre of its length the inferior edge of the lateral flange is embayed to form the sulcus incudis. At this point its dorsi-ventral depth is small, but behind this point it swings ventrally, increasing in depth, to join the anterior face of the crista parotica as a fairly stout flange. The parotic crest is excavated medially to this last, and at the depth of this excavation the posterior wall of the capsule is perforated by a fairly large foramen. This is the posterior facial foramen, and it is seen in the postero-medial and inferior face of the parotic process. The cavity is largely filled by the stapedius muscle, which arises from its walls; the facial nerve runs backwards along its medial wall.

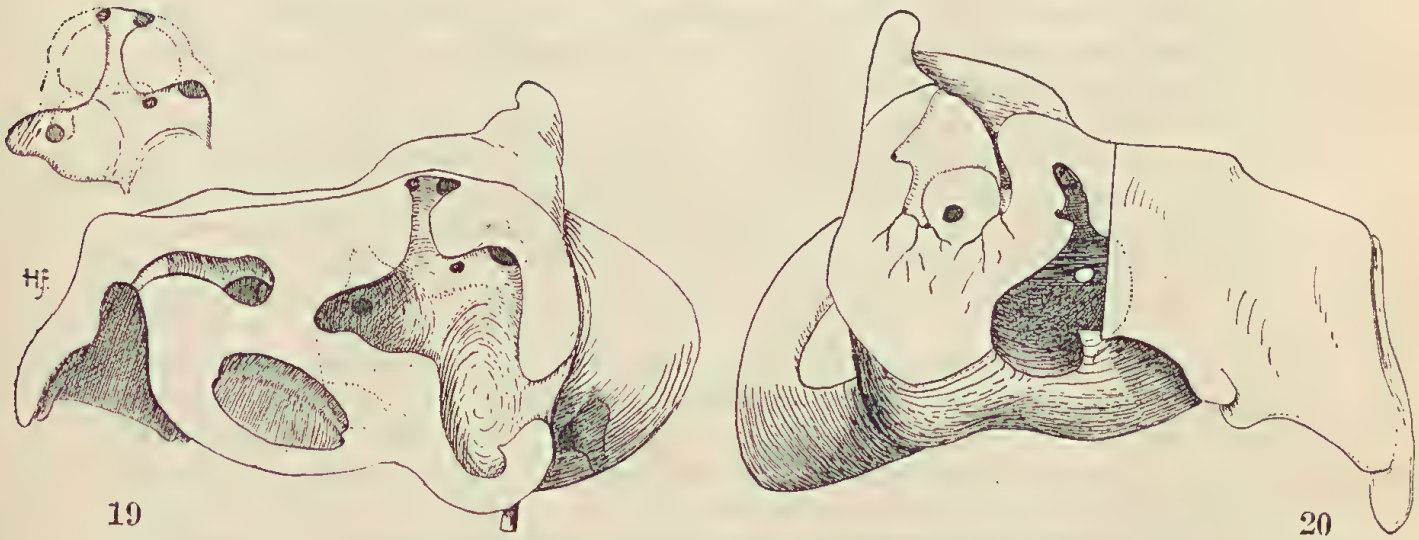
The fate of the tegmen and its processes may be mentioned here. The tegmen itself is largely absorbed setting its processes free from the capsule. The anterior transverse flange becomes the processus anterior of the os tympani. The longitudinal vertical flange becomes one of the accessory auditory ossicles, and the solid process

immediately behind and to the outer side of it becomes the other. The processus posterior of the tympanic bone is formed from the crista parotica and the portion of the ridge bearing the sulcus incudis.

Turning our attention next to the dorsal surface of the capsule (Figure 15), the most obvious feature is the large internal auditory meatus. In the antero-lateral corner of this, the internal aperture of the canalis facialis is readily recognisable. One cannot, however, recognise the usual superior and inferior acoustic foramina so readily. On the other hand the areas and foramina of human osteology are not difficult of identification. A crista transversa very obviously separates a superior, lateral from an inferior, medial fossula.

The foramen for the nerves to the utricle and the ampullae of the anterior and external semicircular canals is placed in the lateral wall of the superior vestibular area in the posterior part of the superior fossula. The canalis centralis and tractus spiralis foraminosa are completely continuous in one large circular aperture and the inferior vestibular area is but faintly differentiated from the area cochlea of the inferior fossula. The foramen singulare in the lateral wall of the inferior vestibular area is not quite comparable with that canal in the human skull, for it transmits a twig of the cochlear nerve as well as that for the ampulla of the posterior vertical semicircular canal. These three canals in the lateral wall of the meatus acusticus internus are clearly shown in my drawing of the medial view of the model (Figure 18).

Posterior to the internal auditory meatus, quite close to the medial edge of my model, there is a small foramen which opens into the labyrinth close to the junction of cochlear and vestibular portions. In the sections this little canal is filled with loose connective tissue, and communicates with the similar tissue between the scala vestibuli and the cartilaginous wall above it. Quite definitely, it does not transmit any blood vessels, and, although it opens dorsally instead of ventrally, I incline to the view that this is a canal for the ductus perilymphaticus.



Figs. 19-20.—A model of the otic capsule and attached parts.
19. Medial section. 20. Lateral section.

The Aqueductus Vestibuli for the ductus endolymphaticus is situated at a higher level lateral to the inferior vestibular area of the internal auditory meatus.

A large triangular orifice lateral to the aqueductus vestibuli gives entrance to the nutrient pit and fissure shown in section in Figure 20.

In a posterior view of the model one notes the position of the large fenestra cochleae, which can be seen from the internal auditory meatus as in the osseous capsule; and the smaller posterior facial foramen (Figure 17) with the proximal end of Reichert's cartilage attached to the crista parotica below it.

Inferiorly the fenestra vestibuli is an obvious feature. Lateral and anterior to this is the tympanic orifice of the facial canal. The facial sulcus runs along the base of attachment of the tegmen tympani, lateral to the fenestra vestibuli, and on into the

fossa for the stapedial muscle in the parotic process and so through the posterior facial foramen (Figure 16).

The Hiatus Fallopii will be found at the fore end of the capsule, high up, lateral to the root of the tegmen tympani, behind the medial extension of the transverse lamina thereof (Figure 19).

The Facial Canal expands almost at once to accommodate the geniculate ganglion; it then continues laterally and ventrally beneath the commissura prefacialis, and then turns posteriorly, burrowing along the attachment of the vertical longitudinal lamina of the tegmen tympani.

The form of the cochlear labyrinth calls for little comment. It is a flattened helix, and the lamina spiralis is but indicated.

The shape of the vestibular portion of the labyrinth and the position of its various diverticula will be gathered by reference to Figures 19 and 20. These are illustrations of the model in section, and in the former of the two drawings I have indicated with dotted lines the recesses which lie lateral to the plane of section. The widely open communication between the vestibular and cochlear portions of the labyrinth has been cut across in Figure 19, and the recess for the common arm of the vertical semicircular canals cut along its length. The recess for the ampullae of the external and anterior vertical canals has been partly opened into, and the orifice of the anterior end of the (future) bony horizontal canal shown in its lower part. The recess for the ampulla of the posterior vertical canal is also partly opened into. The lower portion of the saccular cavity (shown in Figure 20 along with half of the fenestra vestibuli) is indicated in Figure 19 by dotted lines.

Had the plane of section of Figure 19 been two sections further from the mid-line, the roof of the recess for the crus commune would have been found to give way as the aqueductus vestibuli, and in the section itself the passage is found occupied by the endolymphatic duct. In the little drawing above Figure 19 I have indicated the situation of the three semicircular canals.

It will be noted that in the osseous capsule the widely open communication between the vestibular and cochlear portions of the cartilaginous labyrinth has been reduced to quite a relatively small foramen.

It will be noted that the attachment of Reichert's Cartilage is not to the body of the parotic process, but to the floor of the cavum musculi stapedei (Figures 17 and 19).

The Tympanic Cavity is nearly co-extensive with the inferior surface of my model, but extends rather further medially. It is a dorso-ventrally flattened space whose roof medially is a thin membranous and epithelial covering of the inferior surface of the otic capsule, and whose floor is the upper surface of the os tympani similarly covered.

Looking for the tympanic cavity in the sections, beginning with the more lateral, one finds it first as two nearly oval cavities, which enlarge towards the midline, the posterior one more rapidly than the anterior; next the posterior cavity acquires a dorsal extension and again contracts and the partition between anterior and posterior portions peters out and the two communicate uninterruptedly. The dorsal extension of the posterior division, however, continues mediad as a triangular recess in a thickening of the tissue between the capsule and the cavity. This recess still further medially is found to be supported on the manubrium of the malleus and finally to end blindly with the last little segment of the manubrium in front of it. The point of communication of this recess with the rest of the cavity is immediately below the incudo-stapedial joint. The tensor tympani muscle passes forward from that part of the manubrium mallei which thus supports the anterior wall of this little epitympanic membranous recess (recessus manubrii).

The cartilaginous Incus is essentially the same "half anvil" as the bone in the larger specimen; on the other hand, the model I have made of the cartilaginous Malleus presents a different appearance from the bony malleus of the larger specimen. It completely explains the appearance of a suture across the anterior face of the bony specimen. Relatively the cartilaginous specimen is narrower from side to side, and

the manubrium is found folded round from the inferior edge of the body, which is laterally compressed below, and is joined to the lower edge of the thicker upper portion of the body. I am just a little doubtful as to whether this union actually does take place, for unfortunately my section number 36 is exceedingly thick, and a section is missing between this and section numbered 37. There is, however, little room for doubt. In the cartilaginous specimen the lower portion of the body is not so thick as the bony specimen, and the space between the body and the manubrium is not so much filled in. Anteriorly the body of the malleus is produced in ossifying tissue. This is found as a forward continuation of the medial half of the body only and to a lesser distance of the horizontal portion of the manubrium. The plate of ossifying tissue does not expand horizontally to any appreciable extent above, though there is here a slight ridge on its medial face, so that whilst one may say that the inferior horizontal plate of the bony specimen is foreshadowed, one can hardly say that for the smaller superior plate. The proximal end of Meckel's cartilage lies against the concave medial face of this plate of ossifying tissue.

The rounded upper and medial contour of the body of the malleus fits neatly to the posterior curved edge of the longitudinal vertical plate of the tegmen tympani.

The Nasal Capsule.

The correct interpretation of the component parts of the nasal capsule will be made with confidence only by the examination of earlier stages of development than that we are now studying. Already in our specimen the capsule has undergone those changes which result in the peculiar situation of the cavities and nostrils.

That which follows is therefore offered as presenting the probable interpretation of the structures.

In the drawing of the model from the side (Figure 21) the ethmoidal crest, nasal septum, rostral cartilage and presphenoidal cartilage are all readily recognisable.

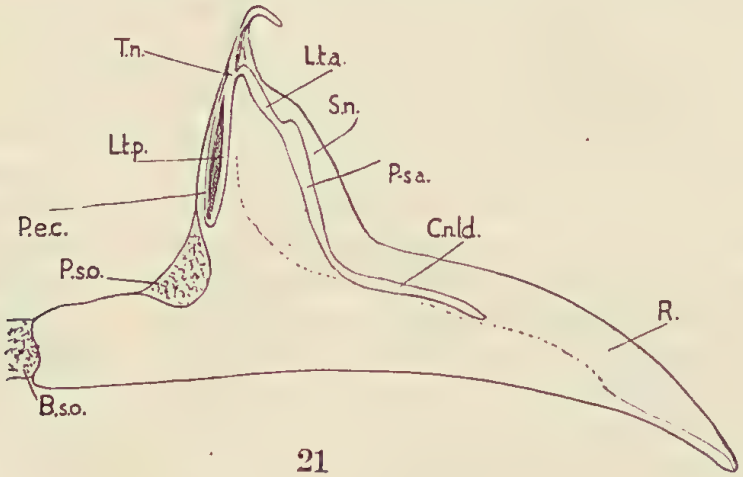
From either side of the upper portion of the ethmoid crest (Figure 22) a vertical plate of cartilage extends laterally. The vertical width of this plate increases as it extends. The lateral margin is sinuate, and it terminates below in a pointed piece which projects beyond the rest of the plate. The tip of the point is joined to the lower corner of the backward-turned lateral edge of a narrow triangular plate which is parallel to, and whose tip is attached to, the larger plate near the dorsal margin thereof. This smaller recurrent plate is placed just in front of the larger. From its infero-medial angle, just in front of the point of attachment to the larger plate, a little cylindrical rod extends horizontally inward towards the mesethmoid crest, but does not reach the crest.

There is a fissure between the lateral margin of the major plate and the inner margin of the smaller, recurrent plate. Through this fissure the olfactory nerves enter the nasal capsule, to reach the sensory epithelium, which is confined to the lateral recess of the nasal cavity.

Turning now to the front of our model (Figure 22), a solid little pellicle of cartilage is found attached to the nasal septum near its anterior margin, high up, on both sides. This branches almost at once into sinuate dorsal and ventral limbs. The dorsal limb curves upward, backward and laterally to join the major and recurrent transverse plates at their point of union. The ventral limb extends downward till it almost comes into contact with the outbulging of the solid rostral cartilage below the septum nasi; it then turns outward parallel with the curve of the rostral cartilage, and then abruptly forward a little distance from the rostral cartilage (Figure 23). In the sections it is found that this ventral limb terminates in front, just medial to and behind the spheno-palatine fossa.

The situation of the olfactory foramen would seem to indicate that the true posterior area of the capsule lies between the recurrent and major transverse cartilages. There is no doubt that the anterior nares have acquired a dorsal situation, and my interpretation of the capsule is based on the assumption that the whole structure has shared in the turning movement which placed those apertures in their dorsal

situation; not only this, but that as the capsules were thus rotated, they were also, so to speak, squashed back, so that the posterior end of the capsule was pushed from the midline on each side.



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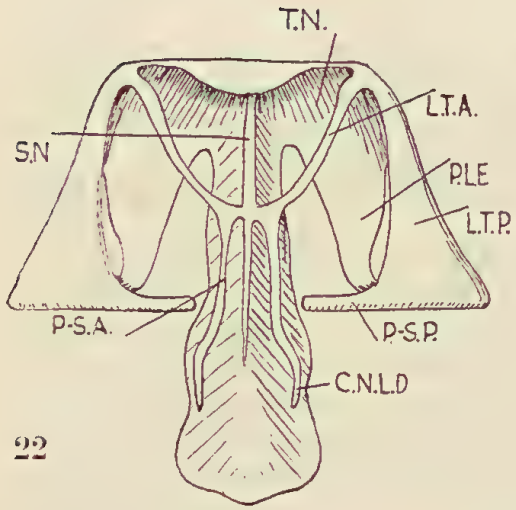

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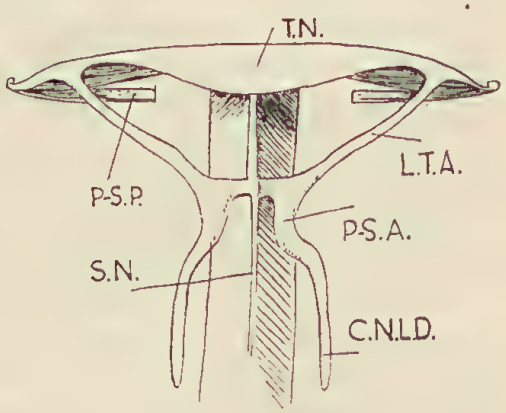


23

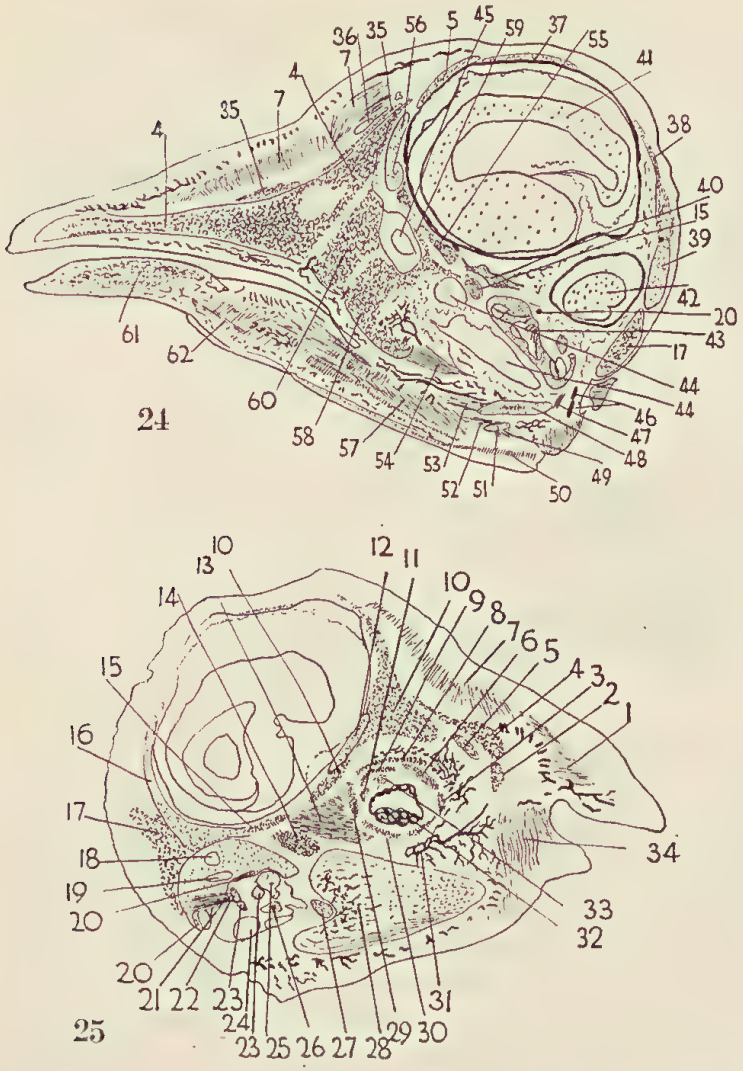
Figs. 21-23.—A model of the nasal capsule and rostral cartilage.
21. Lateral view. 22. Anterior view. 23. Dorsal view.

If this be the fact, then the major transverse plate at once becomes recognisable as the tectum nasi and transverse planum ethmoidale. The superior limb of the anterior sinuate cartilage is the lamina transversalis anterior, the inferior limb is the anterior paraseptal cartilage, and its anterior continuation is the cartilage of the naso-lachrymal duct. The recurrent transverse cartilage is the lamina transversalis posterior, and the cylindrical rod attached to its lower corner is the posterior paraseptal cartilage.

The little forward-turned edge of the tectum nasi alone has heretofore been regarded as the tectum nasi (de Burlet, 1916; Ridewood, 1922).

It will, perhaps, be somewhat difficult to realise how a transversely placed rod can be regarded as a paraseptal cartilage. It appears to me that this cartilage has been pushed outward and rotated into the transverse plane by the backward and lateral movement of the posterior end of the capsule.

Figure 23, a view of the capsule from above, will help one to recognise the superior limb of the anterior sinuate cartilage as the lamina transversalis anterior. The anterior direction of the cartilage of the naso-lachrymal duct is due to the fact that it has retained its relation to the medial, here anterior, corner of the orbit. In view of the fact that the naso-lachrymal duct itself is not developed, this constancy and the persistence of its cartilage at all are of peculiar interest, taken in conjunction with the fact that little remains of what was, in all probability, in the ancestral form a typical mammalian nasal capsule.



1. M. nasolabialis. 2. Lachrymal. 3. M. rectus internus. 4. Maxilla. 5. Frontal. 6. M. obliquus superior. 7. The muscle which opens the blow hole. 8. M. levator palpebrae superioris. 9. M. rectus superior. 10. Frontal. 11. M. rectus superior. 12. Commissura orbito-temporalis. 13. M. pterygoideus internus. 14. Pterygoid process of the squamosal. 15. Alisphenoid. 16. Lamina parietalis. 17. Exoccipital. 18. Nutrient canal. 19. External semicircular canal. 20. Facial nerve. 21. Stapedial muscle. 22. Stapes. 23. Incus. 24. Cavum tympani. 25. Malleus. 26. Manubrium mallei. 27. Meckel's cartilage. 29. M. rectus externus. 30. M. rectus inferior. 31. M. obliquus inferior. 32. Choroid. 33. Optic nerve. 34. M. buccinatorius. 35. Premaxilla. 36. Lateral recess of the blow hole. 37. Parietal. 38. Supraoccipital. 39. Taenia synoticum. 40. Gasserian ganglion. 41. Cerebrum. 42. Medulla. 43. Cochlear branches of the eighth nerve. 44. Lateral pharyngeal recess. 45. Dorso-lateral recess of the naso-pharynx. 46. XI-XII nerves. 47. M. jugulo-hyoideus. 48. Styloid process. 49. M. sternohyoideus. 50. Panniculus carnosus. 51. Hyoid cornu. 52. M. geniohyoideus. 53. M. stylohyoideus. 54. M. tensor palati. 55. Basisphenoid. 56. Planum ethmoidale. 57. M. hyoglossus. 58. Pterygoid bone. 59. Processus anterior ossis pterygoidei. 60. Palatine. 61. Dentary. 62. M. genioglossus.

Figs. 24 and 25.—Sagittal sections Nos. 22 and 38. Embryo measuring 52 mm. from tip of snout to occiput.

Part II.—Myology.

This portion of the work is based upon the examination of one foetal and two young dolphin heads, for which I have to thank Mr. E. Le G. Troughton and the Trustees of the Australian Museum, and also the head of one fully-grown specimen which was kindly procured for me by Mr. McArthur, of the Red Funnel Trawlers Proprietary, Limited, Sydney, and to him also my thanks are tendered.

The Superficial Facialis Musculature.

For the most part the superficial facial muscles are embedded in the deep layer of the superficial subcutaneous fat and fascia. It is, therefore, quite impossible to dissect out the muscles as may be done in the great majority of other vertebrates. It was found, however, that these muscles could be very clearly demonstrated by carefully shaving off the skin and subcutaneous tissues in successive thin layers parallel to the surface. The method gave excellent results, the various muscles being brought very clearly into view layer by layer. In the early trials it was found that the layers removed were too thick, as shown by the fact that the whole of the fibres on the deep side of some of the slices were running in directions different from those on the surface of the slice. This method has the very real drawback that it does not permit the determination of the course of the motor nerves. The innervation of the muscles, however, can be determined on one side of the head, the muscles having been demonstrated on the other.

Before proceeding to the description of the true facialis muscles, it appears advisable to describe the more superficial panniculus carnosus (Figure 26). This has, in part, been regarded by Huber (1934) as portion of the facialis musculature, and certainly does invade the area of the head usually supplied by the platysma. It lies more superficially than the true facial muscles and, unlike those, is not permeated by the connective tissue; but, like the great majority of muscles throughout the vertebrates, presents clean definite cleavage planes between the contiguous tissues and its surfaces, both superficial and deep. The muscle also differs strikingly from the true facial muscles in that its fasciculi are bound in coarse, readily separable, bundles.

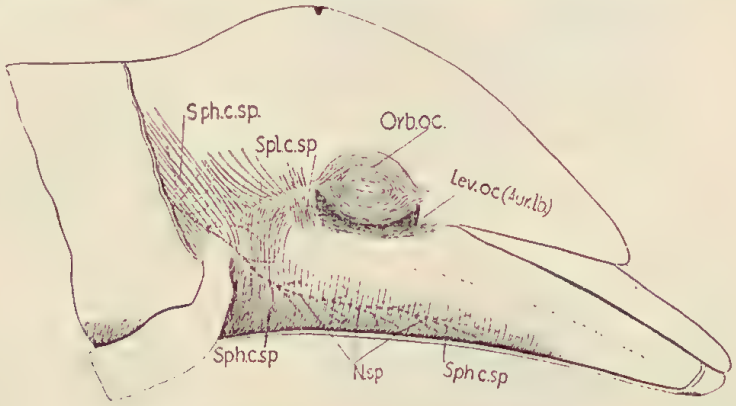


Fig. 26.—The most superficial muscles.

The portion of the panniculus carnosus (50) in which we are interested is that in front of the shoulder girdle. It arises from the superficial fascia a short distance dorsal to the mid-lateral line in uninterrupted continuity with the panniculus of the body generally. There are actually only a few fasciculi having this origin anterior to the shoulder girdle, and these few are continued right round the ventrum to a similar origin on the other side of the body. In front of these, the origin of the dorsal panniculus fasciculi drops to a lower level and the insertion is into the superficial fascia along a line at a slightly lower level than the mid-line of the eye. This small sheet of short fibres extends from the long fibres to the posterior margin of the orbicularis oculi. From the posterior half of the line of insertion of these fasciculi a ventral sheet of fasciculi arises; these are continued round to the other side. In front of these, arising from the same line, there is a small sheet of short fibres which end in the superficial fascia at and a little lower than the level of the ventral margin of the orbicularis oculi. This little sheet of fasciculi lies ventrally to the root of the zygoma.

Immediately below it, and medial to the posterior end of the mandible, the ventral, intermandibular continuation of the panniculus commences. This is a long narrow sheet of fasciculi which arise in the subcutaneous tissues between the jaws along a line which, commencing behind just a short distance within the ventral line of the mandible, gradually approaches the midline to terminate a short distance behind the symphysis menti. The insertion of the fibres is into a similar line on the other side of the intermandibular area.

Explanation of the abbreviations used on Figures 26-29.

Aur.lb., M. auriculo-labialis. Dig.ant. (Csv.lb.), M. digastricus anterior. G.gl., M. genioglossus. G.hy., M. geniohyoideus. H., Humerus. Hy., Hyoid cornu. Hy.gl.l., M. hyoglossus. Hy.gl.m., M. styloglossus. Mx.la., M. maxillo-labialis. My.hy., M. mylohyoideus (Csv.la.). Na.lb., M. nasolabialis. N.sp., A branch of the 4th cervical nerve. N.st.hy., Nerve to the M. sternohyoideus. N.tr., Nerve to the M. trapezius. O.h., M. occipito-humeralis. Orb. oc., M. orbicularis oculi. Orb.oris., M. orbicularis oris. S.-c.m., M. sterno-cleidomastoideus. S.l., Superior laryngeal nerve. Sp., Sensory and motor twigs of cervical nerves. Sph.c.sp., M. sphincter colli spinalis (panniculus). St.th., M. sternothyroideus. Sty.hy., M. stylohyoideus. Sty.hy.p., M. jugulo-hyoideus. Sty.ph., M. stylopharyngeus. Sty.pr., Styloid process. Tr., M. trapezius. V.i.d., Inferior dental nerve. V.my., Mylohyoid branch of the inferior dental nerve. VII.p.a., Preauricular branches of the facial nerve. VII.r.a., Retroauricular branches of the facial nerve.

It is impressed again that all the fibres of the muscle just described are arranged in those coarse, discrete fasciculi which differ so strikingly from the structure of the true facial muscles. This is stressed because it is, in some locations, the only feature on which the identification as panniculus carnosus rests.

Innervation.—The whole of the sheet, with the exception of the short fasciculi behind the eye, is very obviously innervated by one large branch of the fourth cervical nerve. This nerve leaves the anterior trunk of the brachial plexus quite close to the point of emergence of the trunk from the vertebral canal. The nerve becomes superficial below the inferior margin of the sterno-cleido mastoid muscle, but it gives off twigs deep to this muscle and the M. occipito-humeralis, which pass to the portion of the muscle dorsal to the mid-lateral line, and also a branch which passes to the upper ends of those long fibres which arise from the line behind the eye. The main nerve runs right forward on the deep surface of the pars intermandibularis giving off twigs to the muscle all the way along. No nerves were traced to the two short, partly separated, sheets immediately behind the eye (Figure 26).

These two sheets are, of course, right in the position in which reduced remnants of the auricular muscles might be expected, and there is, therefore, a temptation so to identify them. As against this identification the evidence of the similarity of the structure of the sheets and its marked difference from all the facial muscles is so strong as to preclude any other identification than that they are separated portions of the panniculus.

The whole of this sheet of muscle fibres must be regarded as being an anterior extension of the M. constrictor colli spinalis of the Reptilia, and it has been so labelled in the illustration (Figure 26).

In the posthumously published notes already referred to, Huber (1934) identifies the dorsal portion of this constrictor colli spinalis as the sphincter colli primitiva and the ventral portion as the sphincter colli profunda. This was in *Tursiops* and *Monodon*, and the resemblance of the muscles so identified is so close that there can be no doubt that the muscles in all three forms are identical. Huber's identification includes the muscle amongst the superficial facialis muscles; in other words he would regard it as homologous with the dorsal and ventral parts of the constrictor colli facialis of the reptilia, the Cs.2 of our numeration.

Whilst its situation is such as to justify Huber's identification, that evidence appears to be outweighed by the marked dissimilarity of the muscle to the rest of the superficial facialis muscles and by the innervation. One does not overlook the fact that it is quite common to find the posterior portion of the Cs.2 in the Sauria supplied with sensory fibres by the cervical nerves, and the implication that it may be that the innervation of this muscle by the fourth cervical may also be sensory. Admittedly this is a possibility, but the complete continuity of the muscle with the panniculus carnosus above, between and behind the shoulder girdle, together with the similarity of muscular structure, leads to the conclusion that we are in the presence of a peculiar anterior expansion of the spinal muscle.

The M. Orbicularis Oculi (Figures 26, 27).—As is usual in the Theria generally, this muscle extends into the deeper layers of the skin itself and is the most superficially placed of all the facial muscles. Its more centrally placed superficial fibres describe complete ovals around the eyelid; those placed further out diverge as indicated in Figure 26. In deeper layers the fibres again group themselves into two groups—those which complete the oval and those, more peripherally placed, which are inserted into anterior and posterior tendinous intersections which are firmly bound to the temporal bone anteriorly and to the zygoma posteriorly. The posterior superficial fibres which diverge both anteriorly and posteriorly present a peculiarity which appears to be *sui generis*, but it is possible that the most posterior of these are a 'rest' of the attrahens aureum.

The peripheral superficial fibres which run ventrad and rostrad to end in the skin immediately behind the gape, together with a small group of fibres arising in front of the eye (1), constitute a M. naso-labialis (Figure 27).

The M. orbicularis oris (Figure 27) is represented by a small set of fibres immediately in front of the last muscle. These are placed nearly as superficially as the M. orbicularis oculi behind and below the gape, but as they curve forward and dorsally above the angle of the gape they pass more deeply and come to underlie the muscle which is described next.

The M. maxillo-labialis (Figure 27) pars orbitalis arises from the maxilla medial to and in front of the orbit. These fibres pass forward with a ventro-lateral inclination and terminate in the superficial tissues of the cheek above the hinder end of the gape.

The pars profunda of this same muscle takes its origin from the premaxilla some distance further forward and its fibres pass laterally with a caudo-ventral inclination to terminate in the tissues of the lip deep to the pars orbitalis.

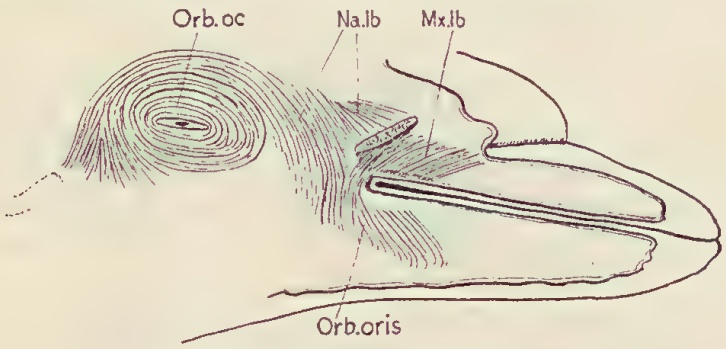


Fig. 27.—The superficial facialis muscles.

An incomplete M. buccinatorius (34) is formed by the anterior portion of the orbicularis oris and this pars profunda of the M. maxillo-labialis, but the two sets of fibres are separated by quite an appreciable distance.

Below the orbicularis oculi there is a muscle whose superficial fibres take their origin from the root of the zygoma, and from there run forward to terminate in the deep tissues of the cheek immediately behind the angle of the gape. These fibres may be regarded as constituting a modified M. auriculo-labialis (Figure 26). The fibres of this muscle, which lie more deeply, curve upward and forward below the orbit to be attached to the antorbital process of the frontal bone. They constitute an auriculo-temporalis and function as a levator bulbi oculi. The deepest of these fibres are parallel with and bound to the splint-like malar bone.

The mass of the 'melon' is largely made up of the two remarkably extensive muscles, one of these functioning to close the blow-hole, the other to open it.

The fibres of the opener of the blow-hole (7) are inextricably embedded in the dense connective tissue of the melon. The extent of the muscle and the direction of its fibres are best demonstrated by the shaving method used upon the other facial muscles; it can, however, be demonstrated by the ordinary dissection method. The muscle takes its origin from the maxilla and premaxilla in front of the blow-hole, and its fibres pass caudad, with increasing inclination dorsad in the more anterior fibres, to terminate in the tough subcutaneous tissues of the front wall of the blow-hole.

The occluder of the blow-hole is in two halves, right and left. Each half arises from the maxilla on either side of, but behind, the blow-hole. The fasciculi pass forward and mediad to be inserted into the side wall and lateral edge of the front wall of the blow-hole. The fasciculi radiate, so that those arising nearest the blow-hole are inserted low down, whilst those furthest away reach the external end of the hole. This is one of the most peculiar muscles I have seen throughout the whole vertebrate series. Its fasciculi are large and are very loosely knit together. Not only is this so, but they are arranged in layers parallel to the direction of their pull. In the result each half of the muscle is built up as a series of sheets of fasciculi which are vertically placed, but with an inclination mediad both from below up and from behind forward.

Previous investigators (Murie, 1874; Huber, 1934) have described this muscle as being composed of different numbers of leaves. I find that in the dolphin the number of component leaves is largely determined by the amount of patience and skill expended on their determination. As many as eighteen have been demonstrated in one half. The peculiar feature is that when the separation has been effected, the plane of separation is absolutely clean, resembling the typical cleavage plane between separate muscles with different origins or insertions but similar directions. Obviously this peculiar 'fasciculation' in sheets permits untrammelled differential pull, ensuring perfect closure of the blow-hole.

Whilst this muscular structure is without exact parallel elsewhere in the vertebrates, it recalls the divisions in some of the more massive quadrato-mandibularis muscles of the Selachii, and it is of interest to note that the division there was necessitated by the difference in the amount of contraction required to bring the jaws together by muscle parts which were inserted along their length.

The Stapedius muscle (21) arises in a fossa in the posterior part of the petrosal bone and passes directly forward to be inserted into the distal end of the small process of the stapes. The facial nerve issues from the facial canal in the fossa in question, and the nerve to the muscle is given off whilst the main nerve is in contact with the muscle.

The Muscles Innervated by the Fifth Nerve.

The M. digastricus anterior (Figure 28) arises from the lower edge of rather less than the posterior one-third of the mandible. The posterior fibres run nearly directly caudad and constitute the lateral edge of the muscle. The anterior fibres pass caudad and mediad and constitute the medial border of the muscle. The muscle is a flat, relatively thick sheet of fasciculi and is inserted into the superficial edge of the anterior face of the whole of the length of the hyoid.

The innervation is by a tolerably thick branch of the mylohyoid branch of the inferior dental nerve. This reaches its deep surface and immediately breaks up into three main and these into several smaller twigs before penetrating the muscle.

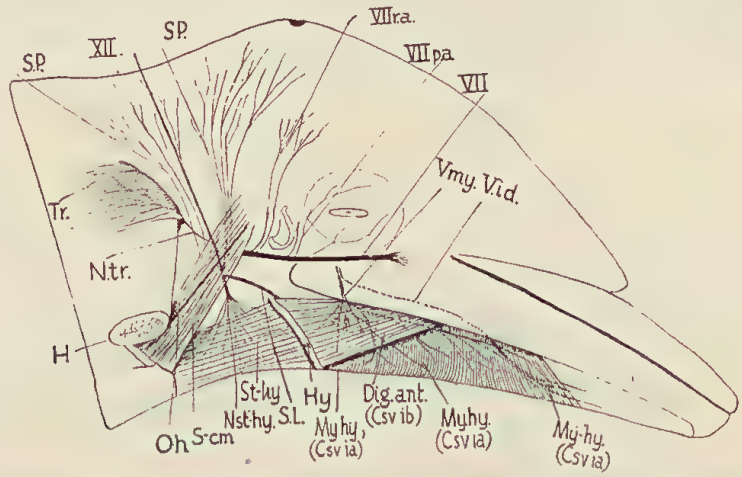


Fig. 28.—The muscles exposed by the removal of those shown in Figures 26 and 27.

The Mylo-hyoid muscle (Figure 28) is very extensive, recalling that of the Ungulata rather than any carnivore. Its fasciculi cross the midline without interruption. Posteriorly the muscle arises from a deeply placed mandibulo-hyoid ligament, which is really the anterior, thickened margin of a fascia which arises from the posterior end of the mandible and passes across, deep to the M. digastricus anterior, between that and the styloid muscles, to be bound to the cranial half of the styloid cartilage and the outer third of the hyoid cornu. Anterior to this ligamentous origin the muscle arises from the inner surface of the mandible some distance dorsal to its inferior edge. This line of origin extends forward to the junction of the anterior and middle thirds of the

length of the mandible. Posteriorly the fasciculi have a slight caudal trend, anteriorly they have a fairly sharp inclination forward, and at the extreme anterior end the fibres interlace in the midline.

The muscle is innervated by numerous fine twigs from the long terminal branch of the mylo-hyoid nerve. These reach the muscle on its ventral surface—that is, of course, the superficial surface.

Muscles of Mastication.

The Masseter is a relatively small muscle; its fibres arise from the inferior edge and inner surface of the malar process of the squamosal bone. Passing ventrad and rostrad these fibres are inserted directly into the superior margin of the dentary in front of the tip of the low coronoid process.

The Temporal muscle arises from the parietal bone and the superior surface of the squamosal. It supplies the greater part of the posterior wall of the orbit, and its fibres run forward, laterally and ventrally, gathering to a short stout tendon which is inserted into the tip of the coronoid process.

The External Pterygoid arises from the lateral plate of the pterygoid bone and from the ascending lamina of the palatine in front of it. It is inserted into the dentary medially to and in front of the M. massetericus.

The Internal Pterygoid (13) arises from the internal plate of the pterygoid bone and from the fossa between the two plates. It is inserted into the coronoid process just in front of and below the insertion of the M. temporalis.

The Tensor Tympani arises from the processus anterior of the tympanic bone. Its fibres run straight back and converge, to be inserted into the dorsal and medial edge of the anterior surface of the malleus.

The Tensor Veli Palatini (54) arises from the hamular process of the pterygoid bone. Its fibres radiate caudad and laterad into the soft palate and are inserted into the tough tissues thereof.

The Post-hyoid Longitudinal Muscles (Figures 28, 29).

The sterno-hyoideus muscle is an exceedingly massive muscle at its origin from the relatively deep anterior surface of the sternum deep, to the insertion of the sterno-cleidomastoid muscle. As this muscle extends to its insertion, along the whole of the posterior margin of the hyoid, it grows rapidly thinner.

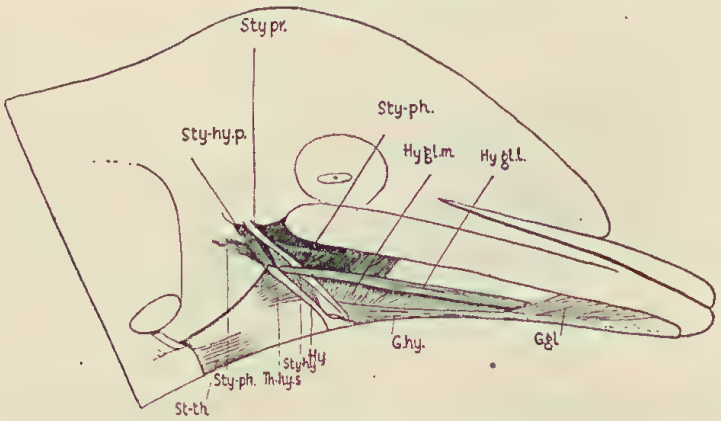


Fig. 29.—The deeper muscles of the pharynx and the tongue.

Innervation: This is from two sources. (1) A remarkably thick branch of the XII nerve breaks up into nine large nerves, all of which enter the muscle and break up into a brush of fine twigs within it. There are, in all, between forty and fifty of these fine nerves. (2) A fairly thick branch from the cervical plexus also terminates in this muscle, splitting into five branches after it enters the muscle.

This exceedingly lavish supply of nerves is apparently quite unique amongst the vertebrates; no other muscle even approaches this rich supply. The most careful dissection failed to discover any one of these many nerves emerging from the muscle again.

The Thyro-hyoid muscle is entirely covered ventrally by the M. sterno-hyoideus. The origin of the muscle is from the ventrum of the thyroid cartilage close to its lateral edge and not far posterior to the hyoid. The fasciculi run nearly straight forward, diverging slightly, so that the muscle is slightly broader at its insertion into the lateral half of the hyoid cornu than it is at its origin.

Innervation: This is by a twig from the division of the XII, which innervates the M. sterno-hyoideus.

The Sterno-thyroid muscle arises from the anterior face of the sternum deep to the M. sterno-hyoideus. Its fibres run straight forward to be inserted into the posterior edge of the thyroid cartilage on either side of the midline.

Innervation: by the same nerve as the last muscle.

THE PREHYOID LONGITUDINAL MUSCLES AND THE INTRINSIC MUSCLES OF THE TONGUE (Figure 29).

The Genio-hyoid muscle is divided into right and left halves anteriorly, but in the posterior half of their length the two halves are completely blended in the midline. The origin of the muscle is from the body of the hyoid and the medial end of the styloid process, and the insertion is by a fascial ribbon into the symphysis menti and into the inferior edge of both rami for a short distance behind the symphysis.

Innervation: This is by the anterior division of XII.

The Hyo-glossus is a long narrow muscle which arises from the extreme lateral end of the hyoid cornu and runs forward along the greater length of the ventro-lateral margin of the tongue and is inserted, deep to the posterior margin of the genio-glossus muscle, into the tissues of the ventrum of the tongue.

Innervation: Anterior division of XII.

The Genio-glossus muscle arises from the ventral edge of the rami of the jaws anteriorly and passes caudo-medially to be inserted into the tissues of the ventrum of the tongue deep to the fascial band of the M. genio-hyoideus.

Innervation: Anterior division of XII.

The Stylo-glossus is a relatively extensive muscle. It arises from the medial third of the length of the styloid process, in front of the hyoid. The most lateral fasciculi take an almost transverse direction around the base of the tongue, the most medial a nearly longitudinal. The intermediate fasciculi take up the intermediate directions. The insertion is into the dense tissues of the side and ventrum of the tongue.

Innervation: Anterior division of XII.

The Stylo-hyoideus muscle arises from the middle third of the length of the styloid process and is inserted into the greater part of the length of the hyoid cornu. The direction of the fasciculi is almost directly mediad.

Innervation: By a fine twig of the facial nerve.

The Jugulo-hyoideus muscle (47). That which has been thus identified is a comparatively small, nearly cylindrical muscle which arises from the basioccipital bone immediately to the medial side of the periotic and medial to and just behind the attachment of the styloid process to the periotic. The insertion is into the lateral tip of the hyoid cornu.

Innervation: Glosso-pharyngeal.

The Stylo-pharyngeus and the Superior Constrictor muscles of the Pharynx are both probably represented by a triangular sheet of fasciculi which arise from the base of the skull medially to the periotic and converge to be inserted into the fascial structures which bind the styloid process and the hyoid to one another and to the larynx. This insertion is deep to the Mm. stylo-hyoideus and jugulo-hyoideus.

Innervation: Glosso-pharyngeal.

THE 'ACCESSORY' MUSCLES (Figure 28).

The Mm. trapezius and Sterno-cleidomastoideus have been regarded as muscles properly innervated by the nervus accessorius. Their innervation has been made the subject of a series of studies by Howell and his colleagues. With Straus (1936, p. 398),

he states that the accessory field of musculature is always present in mammals, "except in Cetacea there uniformly is a M. trapezius . . . a part representing a sterno-cleidomastoid always is present, even in Cetacea".

In the Dolpin there is apparently a normal sterno-cleidomastoid and two muscles representing the trapezius.

The M. Sterno-cleidomastoideus.—The origin of this muscle has been transferred from the petrosal to the exoccipital immediately medial to and behind it. It is a stout, flat muscle whose direction is caudad, mediad and ventrad from its origin to its insertion, without any division, into the anterior edge of the sternum and the clavicle close thereto.

The M. Occipito-humeralis probably represents that portion of the M. trapezius which arises from the occipital bone and from the neck. This also is a flat muscle. It arises from the exoccipital bone immediately above the line of origin of the last muscle, so that it overlaps the greater part of it at and close to their origins. The insertion is into a tubercle on the anterior surface of the humerus just distal to the head of that bone.

The rest of the M. trapezius is probably represented by a thin sheet of muscle fasciculi which arise from the lateral spine of the axis vertebra and from the fascial sheath of the lateral trunk muscles. These fasciculi run backwards horizontally and are inserted into the fascial sheath of the scapulo-humeral muscles. It may be remarked that there is no spine on the dorsal surface of the scapula of *Delphinus*, and this, probably, accounts for the insertion into the fascia.

Innervation: The sterno-cleidomastoid and the occipito-humeralis muscles are innervated by a branch of the vago-accessorius trunk which is given off just outside the cranial foramen. Doubtless this is composed largely, if not entirely, of fibres from the nervus accessorius.

The little trapezius muscle, however, appears to be innervated only by cervical nerve fibres. The nerve to the muscle is given off from the first trunk of the brachial plexus, but beyond the junction of the commissure from the cervical plexus, so that it cannot be determined by dissection whether the muscle is innervated by cervical or brachial plexus fibres.

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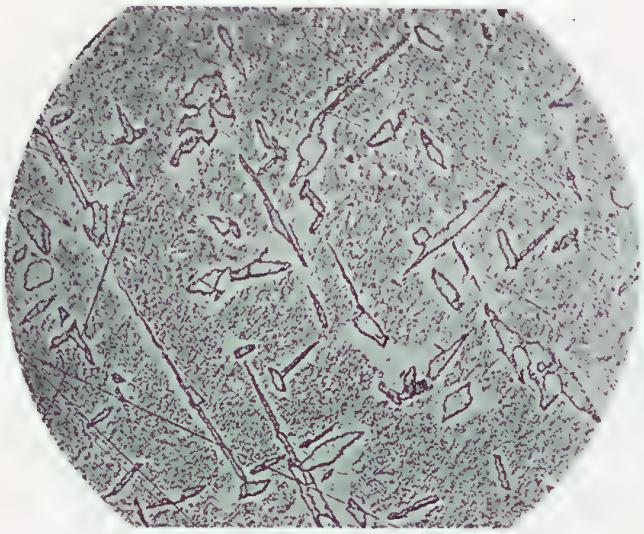

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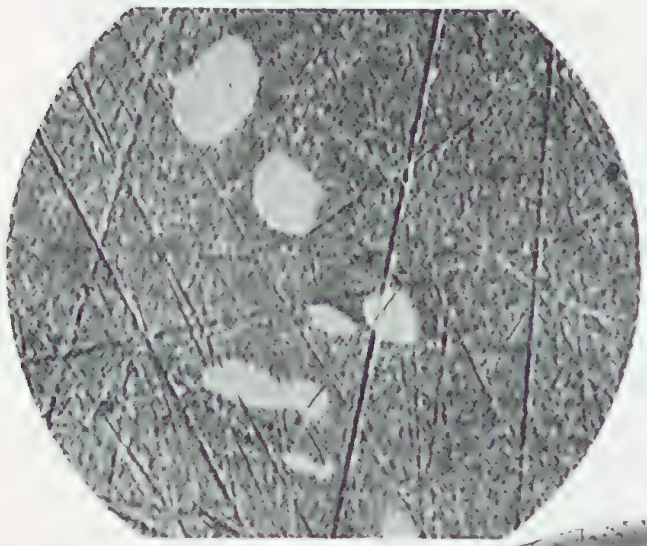

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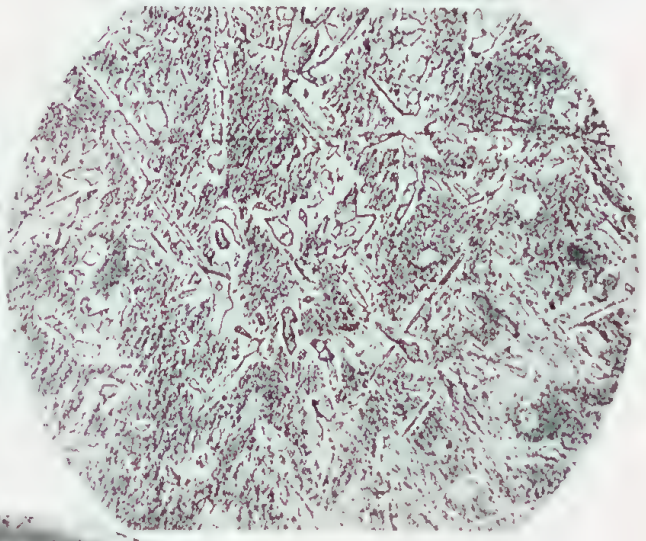

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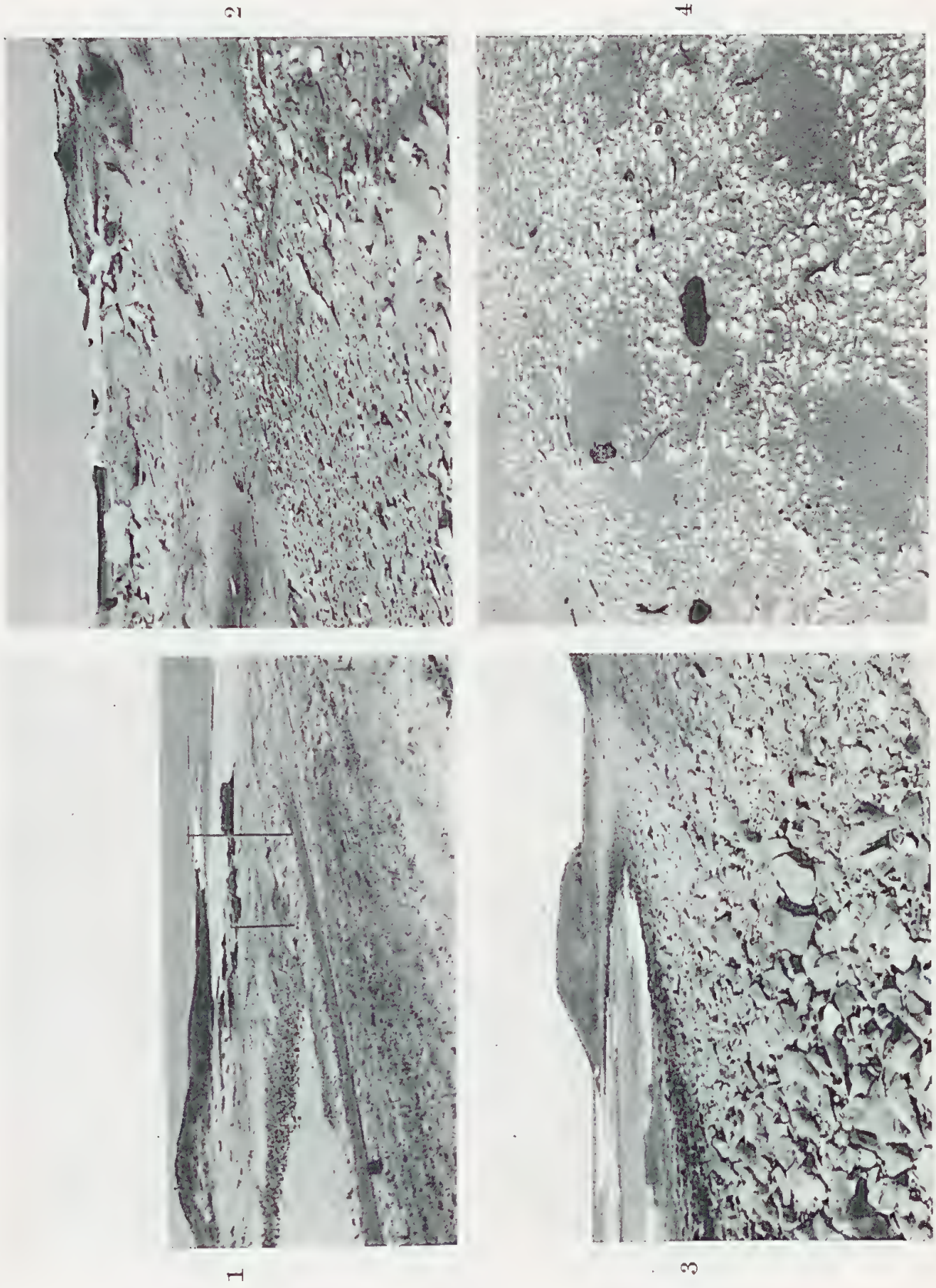

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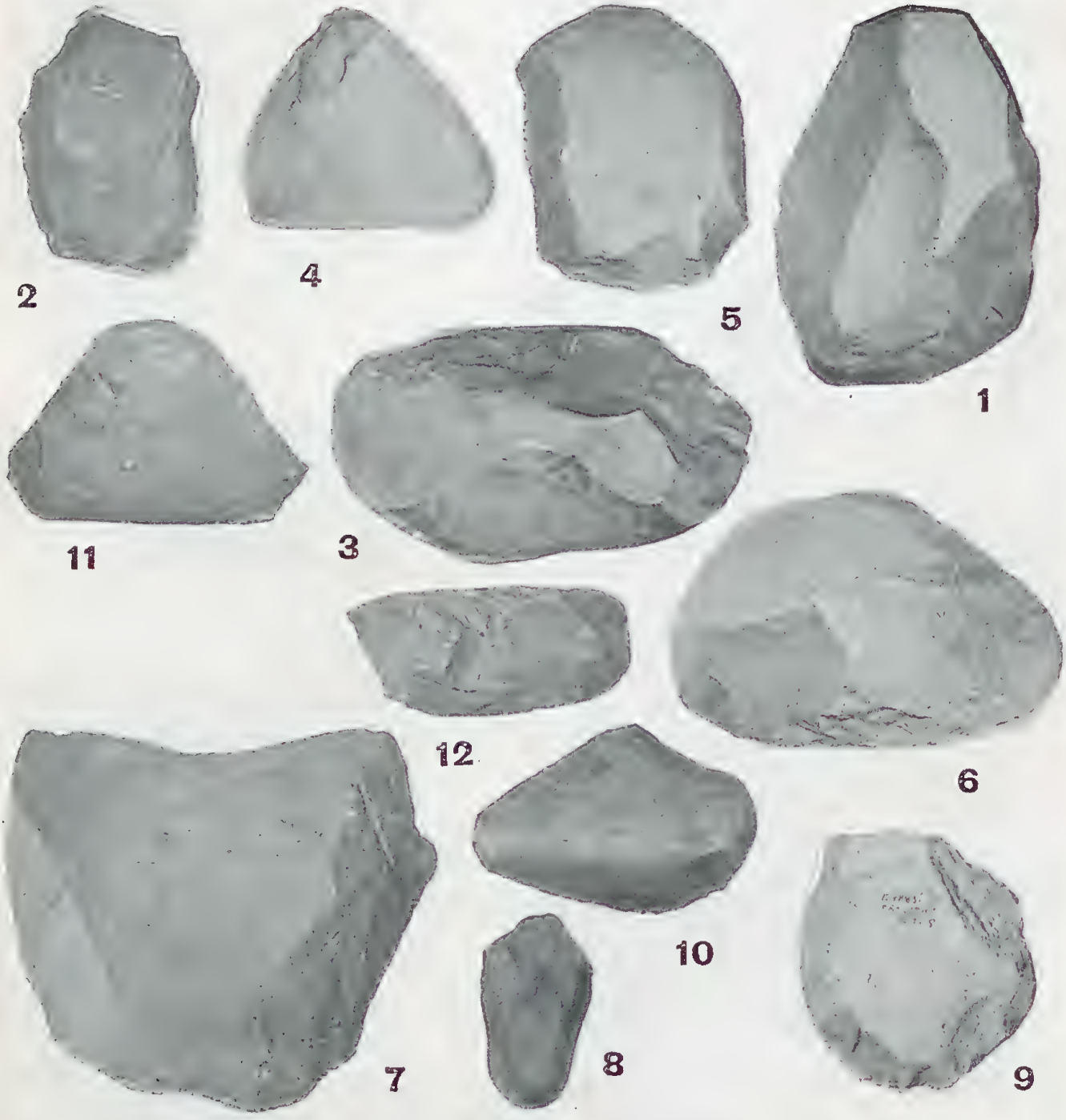
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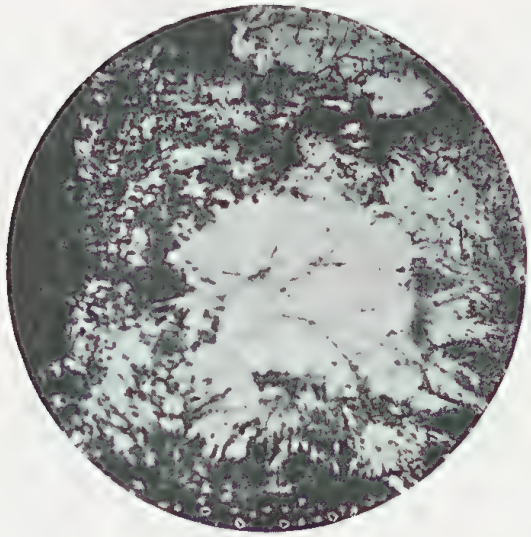
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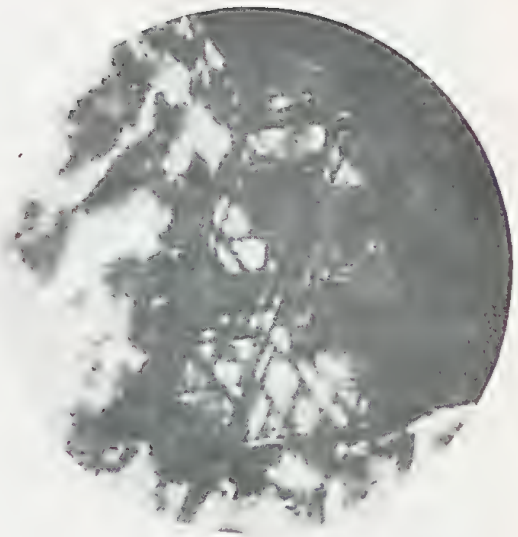
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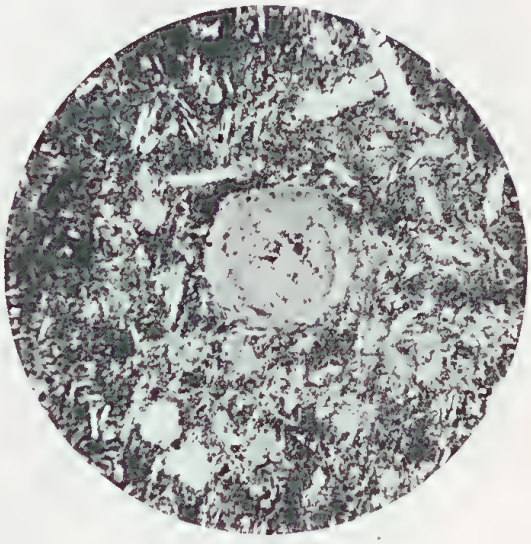
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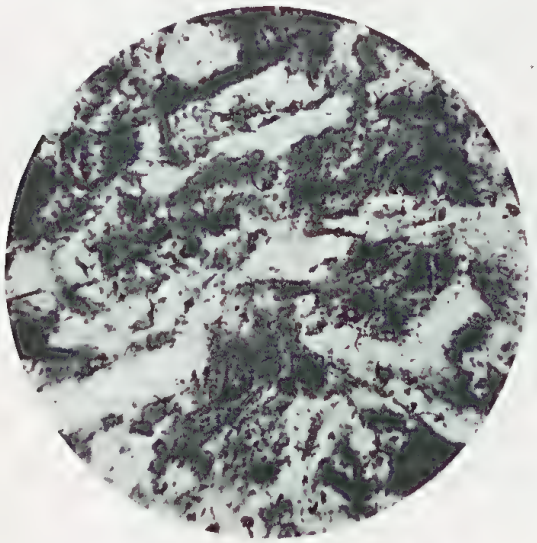
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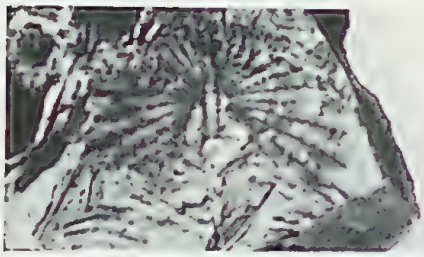

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AUSTRALIAN CERAMBYCIDAE. VI.

Descriptions of New Species Mostly from Queensland.

By Keith C. McKeown,
Assistant Entomologist, the Australian Museum.

(Figures 1-11.)

This paper contains descriptions of two new genera, thirty-four new species, and the redescription of one species, the validity of which has hitherto been doubtful, and notes on several others. Much of the material is in the Australian Museum collection, but I am again indebted to Mr. A. R. Brimblecombe, Assistant Research Officer, Department of Agriculture and Stock, Brisbane, Queensland, who has sent me many specimens of exceptional interest and has permitted me to describe those species which appeared to be new to science. Judging from the richness of the material received from Mr. Brimblecombe and from other sources, it would appear that the Queensland Cerambycid fauna still contains many fine species which await description.

Genus Didymocantha Newman, 1840.

Didymocantha gracilis sp. nov.

♂. Slender; red-brown varied with black and yellow. *Head* large, much broader than prothorax at its widest point; eyes large, coarsely granulate, almost contiguous; antennary tubercles small and inconspicuous; base and vertex closely punctate; median groove shallow, indistinct, but very strongly defined between antennary tubercles; frons depressed, concave, punctate; a prominent tubercle situated below eye; a few scattered colourless setae on apex and between eyes. *Antennae* brown, pubescent, more than twice as long as body, rather coarsely punctate; basal joint broad, thickened, expanded on one side at apex, coarsely punctate, nitid; joints 2–3 black, 4 clouded with black; joints 3–5 stout, remainder slender; joint 3 short; 4 almost twice as long as 3; 4–7 approximately equal, longer than 3; 8–10 approximately equal, longer than 4; apical joint almost as long as 8, slender, basal half yellow. *Prothorax* longer than wide, parallel-sided, with 2 or 3 small flattened lateral tubercles, disc very coarsely punctate with an indication of a small median tubercle near base; base and apex not marginate; disc with a few scattered pale stramineous setae. *Scutellum* narrow, rounded posteriorly, densely pilose. *Elytra* almost twice as wide as prothorax at base, nitid, coarsely punctate, with 2 raised concolorous costae on each elytron running from shoulder and uniting near but not at apex; a dark pitchy-brown patch over basal area and extending narrowly between suture and first costa to about $\frac{2}{3}$ length, becoming black apically; a linear yellow area on first costa at about half-way, and an additional narrow, elevated yellow mark about $\frac{3}{4}$, between costa and suture; remainder of elytra brown; a few scattered hairs near apex. *Legs* slender, ferruginous; femora slightly clavate; tibiae ringed with a broad yellow band near apex. *Under surface* reddish, pilose; sterna coarsely punctate. Long. 10 mm.; lat. 5 mm. Antennae 24 mm.

Hab.—Queensland: Bunya Mts. (A. J. Turner), February 1931. Holotype in Queensland Museum.

Comes nearest to *D. novica* Blackburn, but differs in the strong elytral costae, the strongly marked colour pattern, and ferruginous legs. The form of the prothorax readily separates it from *D. brevicollis* Pascoe.

Genus Notoceresium Blackburn, 1901.

Notoceresium elongata sp. nov. (Figure 1.)

♀. Elongate, slender, subnitid, and flavo-castaneus. *Head* broad, rounded, as broad as prothorax at widest, strongly constricted posteriorly; a deep impressed median line

extending from posterior margin to clypeal suture; clypeal suture almost straight; eyes large, emarginate, coarsely granulate; antennary tubercles inconspicuous, widely separated, intervening area with a few small punctures adjacent to median line. *Antennae* as long as body, bright ferruginous, coarsely punctate, pilose; basal joint long, swelling regularly to apex; joint 3 shorter than 4; 5–7 equal, longer than 4; 8–11 progressively decreasing in length; joints 3–5 stout, remainder slender. *Prothorax* viewed from above almost globular, sides slightly produced but not tuberculate about ¾, sharply constricted on anterior and posterior areas, marginate; anterior margin procurved, anterior, straight; disc centrally slightly depressed, with a few small punctures, subnitid. *Elytra* broader than prothorax at widest, parallel-sided, shoulders prominent, apices acutely rounded; disc slightly shagreened, subnitid, lateral margin strongly, and suture lightly marginate; disc of elytra with two slightly elevated concolorous costae; margin of suture, costae and lateral margin with deep, widely-spaced seriate punctures and 3 longitudinal rows of smaller seriate punctures on lateral declivity, a long slender, almost colourless hair seated in each puncture; elytra bright castaneus with shoulders and lateral areas clouded with black but not reaching to apex on sides. *Scutellum* very small, triangular. *Legs* ferruginous; femora broadly clavate, nitid, slightly pubescent at apex, narrowly pedunculate; tibiae slender, pilose, especially towards apex; apically with two stout black spines; tarsi slender, clothed with dense pubescence mixed with stout hairs. *Under surface* subnitid, clothed with fine yellowish pile on sterna and first and second abdominal segments. Long. 12 mm.; lat. 3 mm.

♂. Similar to female, but smaller and more slender; antennae longer than body, 8th joint reaching to apex of elytra. Long. 10 mm.; lat. 2 mm.

Hab.—Queensland: Bunya Mts., 3,000 feet (N. Geary), a series of twenty-eight specimens collected between January 1928 and February 1940. Holotype ♀ and allotype ♂ in Australian Museum.

Comes close to the genotype, *N. impressiceps* Blackburn, but is readily distinguished by its larger size and large setose elytral punctures.

Notoceresium setistriatus sp. nov. (Figure 2.)

♀. Robust; brown with pale elytral costae. *Head* rounded, ferruginous, considerably broader than prothorax at widest point; sides slightly developed near centre; vertex and frons evenly rounded; strongly nitid, with a narrow impressed median line with close fine punctures towards its anterior extremity; antennary tubercles small, inconspicuous, very widely separated; head not depressed between tubercles; eyes large, prominent, coarsely granulate, deeply marginate, superior lobe tending to become linear, inferior large and globular; cheeks very short; palpi short, pale ferruginous, apical joint short, broad, obliquely truncate. *Antennae* shorter than body, closely punctate, sparsely pilose, dark brown; basal joint stout, cuneiform with unilateral expansion; joints 3–4 equal, shorter than 1; 5–6 equal, slightly longer than 3; 7–8 equal, as long as 3; 9–10 equal, shorter than 3; apical joint shorter than 10, regularly pointed, pale. *Prothorax* globular from above, sides regularly rounded with slight, almost imperceptible tendency to a rounded angle near middle, ferruginous, flattened on disc, with a small median area closely and finely punctate; posterior border marginate. *Scutellum* small, narrowly triangular, acutely rounded behind. *Elytra* broader than prothorax (as wide as head), brown, parallel-sided, broadly rounded apically, nitid, coarsely and shallowly punctate; lateral margin and a slightly raised median costa on disc white, impunctate, not reaching apex; suture marginate, unicolorous; a single longitudinal row of fine erect setae along area between costa and suture; three rows of setae between costa and lateral margin. *Legs* pale stramineus; femora regularly and slightly clavate, not strongly pedunculate, glabrous, nitid; tibiae with a few short, pale setae towards apex; tarsi relatively broad, setulose; claws yellow. Long. 4 mm.

♂ similar to female, smaller, antennae not quite reaching apex of elytra. Long. 3·5 mm.

Hab.—Queensland: Bunya Mts. 3,000 feet (N. Geary), December 1937 (types); Brookfield (H. Hacker), 15 November 1926. New South Wales: Tweed River (W. W. Froggatt), Oct.–Nov. 1901–3. Holotype ♀ and allotype ♂ in Australian Museum.

Wholly unlike any other species in the genus by reason of its pale costae and robust form.

Genus Tessaromma Newman, 1840.

Tessaromma aurata sp. nov.

♀. Slender, ferruginous, clothed with golden pile. *Head* narrow, slightly wider than prothorax at anterior margin, densely clothed with fine golden pile; constricted behind eyes; a deep median groove extending from base to clypeal suture; eyes relatively small, finely granulate; antennary tubercles prominent. *Antennae* scarcely as long as body, slender; basal joint tapering to base, almost straight sided; joints 3–4 equal, short; 5–7 equal, longer than 3; 8–9 equal, as long as 3; 10–11 approximately equal, shorter than 3. *Prothorax* longer than wide, anterior and posterior margins slightly constricted, broadly marginate; disc swollen, with an impressed median line; sides with a broad, blunt somewhat backwardly directed tooth- or thorn-like prominence about middle; densely clothed with fine, recumbent golden pile. *Scutellum* broad, rounded behind. *Elytra* broader than prothorax at widest, parallel-sided, tapering slightly at apex; apices squarely truncate, broadly marginate; shoulders prominent, not tuberculate; disc with a tendency to an obscure raised concolorous median longitudinal costa extending a little past half-way; derm dark ferruginous, subnitid, somewhat irregularly clothed with dense recumbent golden pubescence (irregularity in clothing may be due to abrasion); extremity of abdomen passing elytral apices. *Legs* dull ferruginous, slender, femora irregularly clavate, finely punctate; tibiae moderately slender; a single apical spine on hind tibiae; tarsi elongate, slender; lightly clothed with golden pubescence. *Under surface* with long golden pile. Long. 12 mm., lat. 3 mm.

♂. Similar to female, but more reddish in colour; antennae longer than body, apex of 9th joint reaching extremity of elytra. Long. 11 mm.; lat. 2 mm.

Hab.—New South Wales: Comboyne (H. J. Davidson), 1937 (♀); Queensland: Emu Vale (A. R. Brimblecombe), 10 February 1939 (♂); Holotype ♀ in Australian Museum; allotype ♂ in Queensland Museum.

Near *T. sericans* Er., but differing in the dense clothing of golden pile, and the squarely truncate and margined elytral apices.

Tessaromma loxleyae sp. nov.

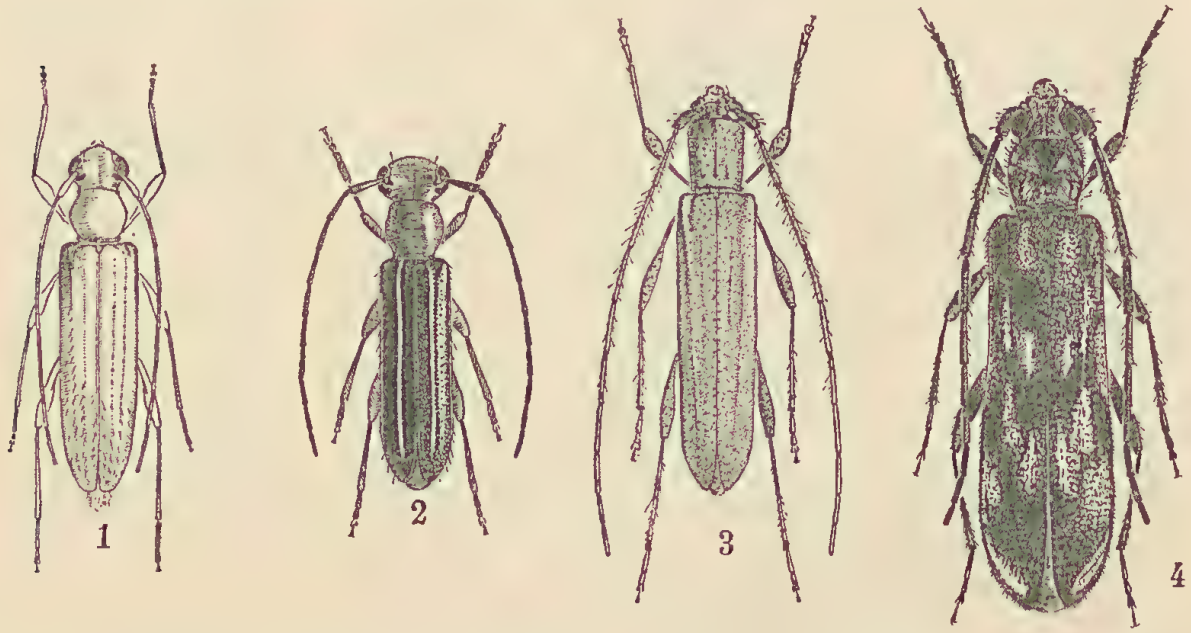
Slender; hyaline varied with spots and patches of brown. *Head* large, broad, constricted at base; a fine impressed median line extending from base to clypeal suture; vertex impunctate, frons finely punctured; eyes large, prominent, strongly emarginate, coarsely granulate; antennary tubercles small, acute, prominent; a strong ridge extending downwards over frons from antennary tubercle to clypeal suture. *Antennae* shorter than body, pubescent, dull yellow; apices of joints narrowly ringed with brown; basal joint narrowly clavate; joint 3 slightly longer than 4, shorter than 5; 6–7 approximately equal, shorter than 5; 8–11 progressively shorter. *Prothorax* exclusive of spines much narrower than head (little more than half as wide), rather strongly constricted behind anterior border; strong, dorsally flattened, recurved lateral spines about middle; anterior and posterior borders slightly curved, strongly marginate, anterior lightly edged with brown; disc with 2 rather laterally situated, well-developed elongate tubercles over which lies a blackish-brown trident-shaped mark with the points directed forwards and a curved linear dark mark on each side between it and lateral spine. *Scutellum* narrow, triangular. *Elytra* narrow, parallel-sided, rounding broadly to apices over apical sixth; apices squarely truncate, unarmed; disc with 2 irregular raised costae, the exterior one bifurcate at base and tending inwards towards suture at apical fourth, expanded near point of contact with sutural margin; the second costa extending from inner arm of bifurcation to about $\frac{2}{3}$ elytral length; base of elytra granulate-punctate, remainder subnitid, lightly and closely punctate laterally; elytra

white to creamy, hyaline, varied with spots and patches of brown, darkest and most continuous over base, with a dark area filling bifurcation of exterior costa; a ?-shaped mark (reversed on left elytron) near apex covering apical portion of costa and sutural margin, together with several small scattered patches; apical half of elytra with sparse erect colourless setae. *Legs* pale yellow; 2nd and 3rd coxae banded with brown, darker and wider on under side; femora strongly clavate, deeply notched on inner margin towards apex (especially strong on 2nd and 3rd pairs); tibiae slender; tarsi elongate, narrow. *Under surface*: thoracic segments black, finely punctate; abdomen yellow, subnitid. Long. 8 mm.

Hab.—New South Wales: Lugarno (Miss Loxley), July 1940. Holotype (unique) in Australian Museum.

A remarkable little species which comes closest in form to *T. undatum* Newman, but is readily distinguished by its peculiar colour pattern, hyaline integument, elytral costae and other structural characters, and small size.

Named for its discoverer, Miss Loxley, of Penshurst, New South Wales, who presented the unique specimen to the Museum.



Figures 1-4.
1. *Notocercsium elongata*, n. sp. 2. *N. setistriatus*, n. sp. 3. ? *Tessaromma setosa*, n. sp. 4. *Opsidota gracilis*, n. sp.

[N. B. Adams, *del.*

? Tessaromma setosa sp. nov. (Figure 3.)

♂. Slender, greyish-brown, hairy. *Head* small, narrower than prothorax; eyes large, prominent, coarsely granulate; antennary tubercles small, not prominent; frons, clypeus, and antennary tubercles densely clothed with pale stramineous pile, long setae of the same colour projecting round mandibles; palpi long, apical joint spatulate, obliquely truncate; mandibles black. *Antennae* slender, longer than body; basal joint elongate, swollen; joints 3 and 6 equal; 4–5 equal, slightly longer than 3; 7–9 equal, shorter than 3; 10–11 shorter than 7, approximately equal; joints 1–10 pilose, pile on basal joint long and lax, 11 sparsely pubescent, subnitid; joints 1–3 with long, pale, erect hairs protruding from pilose covering over entire surface, and on 4–10 forming a sparse fringe. *Prothorax* ⅓ longer than wide, broadening slightly towards anterior border, sides almost straight, with a small lateral tubercle just before middle, clothed with dense grey-brown pile interspersed with scattered long, erect hairs; an indistinct raised median line about middle of length with a short, distinctly flattened line on either side, each lightly margined with long grey pile. *Elytra* almost twice as wide as prothorax at base, parallel-sided, apices narrowly rounded, clothed with close greyish-

brown pile, becoming sparser apically, interspersed with long erect hairs especially over apical area; numerous small glossy pustules on basal area and along suture for about ¾ length; over the whole elytral surface numerous small rounded nitid areas among the clothing tending to form regular lines. *Legs*: femora strongly clavate, shaft extremely slender, densely clothed with grey pile interspersed on expanded portions with numerous small rounded areas of exposed derm; tibiae and tarsi slender, pilose. *Under surface* wholly clothed with grey pile interspersed with numerous small, rounded, naked, nitid areas of exposed derm giving a uniformly spotted appearance; sides of metathorax coarsely punctate. Long. 18 mm.; lat. 3 mm.

Hab.—Queensland: Yarraman (A. R. Brimblecombe), March 1936. Holotype (unique) in Queensland Museum.

I am not entirely satisfied that this remarkable insect should be placed in the genus *Tessaromma*, the shape of the prothorax being altogether unlike that of any of the other allied species, although in other characters it conforms closely to those of the genus. I am reluctant to erect a new genus for its reception, and it appears advisable to place it in *Tessaromma* pending further material becoming available for study. I believe that the specimen before me is a male.

Viewed with the aid of a lens or the low power of a microscope, the whole surface of the elytra appears to be dotted with small shining pustules, but a high power reveals that the majority of these areas are quite flat, circular patches of naked derm showing through the pilous clothing, as described above.

The insect is quite unlike any other in the genus, and its remarkable appearance should render its identification easy.

Genus Piesarthrius Hope, 1834.

Piesarthrius bleeserae sp. nov.

♂. Robust, pale castaneous with sparse black markings. *Head* broad-constricted posteriorly, base coarsely punctate; antennary tubercles small and prominent, median impressed line obscure, wide and shallow; eyes large, very coarsely granulate; head clothed with coarse pale-stramineous hair, densest around eyes, posterior margin and frons. *Antennae* as long as, or very slightly shorter than, body, 9-laminate; basal joint stout, obconical, swollen toward apex, exterior apical angle produced, rounded, black, nitid, with scattered short white hairs; joints 3–10 short, progressively increasing in length; 10th markedly longest and bearing two laminae, each of the remaining joints one; laminae narrow, dull castaneous, very closely and finely punctate, densely pilose, produced on upper side of antenna only, gradually increasing in length from base to apex, on apical three joints of almost equal length. *Prothorax* cylindrical, almost as wide as long, narrower than elytra at base, sides gradually and regularly rounded, widest at centre, posterior border sinuate-marginate, very coarsely and shallowly punctate, some punctures confluent; derm highly nitid; clothed on disc with sparse recumbent stramineous hair, densely clothed on sides with white. *Scutellum* scutiform, narrowly rounded behind, clothed with dense white pile. *Elytra* regularly and gradually tapering; apex broadly rounded exteriorly, strongly unispinose on suture; basal half with very large punctures, some confluent, apical half more sparsely and shallowly punctate; a black lateral patch extending from shoulder to ⅓ elytral length, and an irregular broken transverse black line just past half-way, a broad and roughly U-shaped brown area on apex; centre of elytra palest; clothed with sparse coarse hairs mostly seated in punctures, densest over apical dark area and fringing apex. *Under surface* clothed with greyish hairs, densest along margins of abdominal segments, and a broad stripe of dense white pile extending along sides of thorax just below lateral margin of elytra; sterna coarsely punctate. *Legs* dark ferruginous, clothed with yellowish hairs; a dense brush-like fringe of short stiff pile along lower surface of femora (a character which may be sexual). Long. 22 mm.; lat. 6 mm.

Hab.—North Australia: Darwin (F. H. Taylor), September 1940. Caught at light. Holotype (unique) in Australian Museum.

Named for Mrs. Bleeser, of Darwin, at the request of Mr. F. H. Taylor, the collector.

The very remarkable arrangement of the antennary laminae serves to distinguish this species from all other members of the genus; the colour pattern is also distinctive.

Genus Opsidota Pascoe, 1863.

Opsidota gracilis sp. nov. (Figure 4.)

♀. Relatively slender, pitchy-brown varied with yellow. *Head* small, closely rugoso-punctate, sparsely clothed with recumbent pale-rufous hair; median impressed line clearly defined on vertex only, nitid; eyes medium, coarsely granulate; bases of mandibles coarsely rugoso-punctate. *Antennae* not reaching extremity of body, slender, basal joint obconical, strongly curved, closely punctate, nitid, with sparse erect hairs; remainder pilose with erect hairs; joint 3 longer than 4, closely punctate; 4–7 subequal; 8 shorter than 7; 9 shorter than 8; apical joint much shorter, cylindrical; joints 4–7 apically unilaterally angulate and slightly produced. *Prothorax* longer than wide, cylindrical, sides slightly and regularly rounded; anterior margin procurved, posterior straight; disc coarsely rugoso-punctate with an elongate nitid area in centre; 5 large round bright rufus pilose spots on disc, and 3–4 smaller lateral ones. *Scutellum* scutate, pointed behind, clothed with fuscous pile. *Elytra* much wider than prothorax, parallel, widening very slightly to apex; very coarsely and shallowly confluent-punctate with indications of 3 indistinct raised costae much obscured by puncturation, one running close to and parallel with suture, the second rising inside shoulder and inclining gradually inwards until it appears to junction with 1st costa near apex, 3rd commencing on shoulder, parallel with lateral margin, extending about half-way; apices broadly rounded externally, roundly dehiscent, forming a broad regular point, unarmed; sparsely clothed throughout with short recumbent white hairs interspersed with erect black hairs which are thickest near apex. The pitchy derm is varied with small, irregular yellow areas, which, to the naked eye, appear to form 2 obscure pale fasciae. *Under surface* pitchy, glabrous, nitid; prothorax finely rugoso-punctate; mesothorax very closely and finely rugoso-punctate; metathorax and abdominal segments with sparse fine punctures. *Legs* slender, black, finely punctate, with erect black hairs. Long. 19 mm.; lat. 5 mm.

♂. Similar to female, but smaller; antennae considerably longer than body, compressed; joints 3–10 progressively increasing in length, apical joint longest; 3–10 with unilateral apical expansion; pale elytral clothing much denser. Long. 15 mm.; lat. 4 mm.

Hab.—Queensland: Injune (N. Geary), 2 November 1939. Holotype ♀ and allotype ♂ in Australian Museum.

Comes nearest to *O. infecta* Pasc., but is easily distinguished by its slender form, elongate prothorax and coarse sculpture.

Genus Coptopterus Hope, 1834.

Coptopterus hirsutus sp. nov.

♀. Robust, stramineous with irregular black elytral markings. *Head* ferruginous, broad, with small and widely separated punctures, uniformly clothed with coarse, sparse pale stramineous hair extending over sides of muzzle and obscuring exterior face of mandibles, clothing especially dense in concavity of eye; antennary tubercles not prominent, nitid, clothed with hair. *Antennae* not reaching beyond second segment of abdomen, ferruginous; basal joint finely punctate; joints 1–5 clothed with coarse hair; 6–11 with short, close pile; joint 3 equal to 5; 4 shorter; 6–7 equal to 4; 8–10 approximately equal, shorter than 8; terminal joint compressed, slender, slightly notched laterally near apex. *Thorax* as broad as long, sides almost straight but contracting slightly anteriorly, dark ferruginous, very coarsely and irregularly punctate, somewhat thickly clothed with coarse pale-ferruginous to whitish hair; clothing on posterior margin concentrated into 3 patches, giving the appearance of short white lines; anterior

margin straight, posterior sinuate, narrowly marginate. *Scutellum* narrow, lingulate, posteriorly rounded, densely pilose; pile white. *Elytra* considerably wider than base of prothorax, parallel-sided, apices emarginate, acutely bispinose, lateral spine stouter than sutural, spines black; pale stramineous to cream, with a roughly triangular area extending from shoulder to suture at about one-fourth length, tinged with strong ferruginous-yellow, derm of this area highly nitid; 3 short and narrow longitudinal black markings near base, one behind and slightly inwards from shoulder, the 2nd near lateral margin and behind first, the 3rd and longest level with and parallel to this and close to suture, an irregular broken but somewhat W-shaped narrow transverse black marking at about $\frac{2}{3}$ elytral length, an irregular black to ferruginous area developing from a longitudinal line and expanding over greater part of apical $\frac{1}{4}$, suture ferruginous, lateral margin ferruginous tending to black at apex; basal half of elytra very coarsely and irregularly punctate, middle $\frac{1}{3}$ coarsely, and apical $\frac{1}{3}$ rather finely, punctate; distribution of punctures tending to form 3 indistinct and impunctate unicolorous longitudinal costae on basal $\frac{2}{3}$, the central one extending to near apex where it is black; the whole elytron somewhat densely clothed with long, coarse, pale-stramineous hairs seated in punctures. *Legs* dark ferruginous, clothed sparsely with long white hairs, joints black; tarsi fringed with short yellow hairs. *Under surface* wholly clothed with dense decumbent white hairs. Long. 31 mm.; lat. 7 mm.

♂. Similar to female but more slender; antennae reaching to apex of elytra; joints 1–3 with hairy clothing, the remainder pilose. Clothing of under surface less dense. Long. 29 mm.; lat. 6 mm.

Hab.—Queensland: Bunya Mts. (N. Geary), 12 February 1940. Another example received from Mr. A. R. Brimblecombe is from Toowoomba, Queensland, 21 December 1928 (W. B. Bernard); it measures 28 mm. in length. Holotype ♀ and allotype ♂ in Australian Museum.

This species comes nearest to *C. musgravei* McKeown, but differs in the shape of the prothorax, the clothing and proportions of the elytral joints, the form of the scutellum, and other features.

Genus Uracanthus Hope, 1833.

Uracanthus insignis Lea.

Trans. Roy. Soc. S. Aust., xl, 1916, p. 370.

The specimen of this fine species of *Uracanthus* before me differs in many respects from the original description by Lea, but I have no hesitation in placing it with *insignis*. It is, I consider, a female; that described by Lea appears to be a male. The characters of both male and female are set out below for purpose of comparison—that of the male is based on Lea's description and checked by two specimens in the Museum.

♂. *Head*: muzzle about twice as long as wide; clypeus with a few conspicuous punctures, rounded posteriorly with the suture deep, triangular, and wide in the middle. *Antennae* thin, not passing 3rd abdominal segment, fifth to tenth joints rather feebly produced to one side at apex, tenth about $\frac{2}{3}$ the length of eleventh. *Prothorax* much longer than wide, base about twice as wide as apex; glabrous portion with about 20 conspicuous corrugations, but irregular and with a small node on each side of middle. Elytra narrow, almost parallel-sided, each widely emarginate and strongly and acutely bispinose at apex, with remnants of feebly elevated lines; with dense and minute punctures, but on

♀. *Head*: muzzle almost twice as wide as long; clypeus rather densely and coarsely punctate, slightly rounded posteriorly; suture deep, triangular and wide in the middle. *Antennae* thin, not passing 3rd abdominal segment; fourth to tenth joints rather feebly produced at one side at apex, tenth equal in length to eleventh. *Prothorax* much longer than wide, base about twice as wide as apex, tapering much more regularly and with lateral tubercle much less strongly developed than in male; glabrous portion with about 25 conspicuous corrugations, but irregular and with a small node on each side of middle. *Elytra* narrow, almost parallel-sided, very slightly emarginate and

basal ⅓ with rather large partially concealed ones. *Legs* thin, but not very long.

The clothing on the head is rather dense, but the muzzle, sides in front of eyes, base, and under surface are glabrous or almost so; the prothorax is widely glabrous along middle (widest in front), the pubescence on each side of the glabrous space appearing as a narrow white line; between each of these and the side, the pubescence is stramineous, then there is another white line, narrow at the apex and broad at the base; the scutellum and the suture for a slight distance beyond it are glabrous, then the suture for a slight distance is clothed with white pubescence, but from about the basal ⅓ is narrowly dark brown and glabrous (although not conspicuously so), the apex of each elytron (for a space of about ⅔ as long as its width) is highly polished and much darker (the spines are black); on the under surface the clothing is white or whitish.

Dark piceo-castaneous, elytra (apex and suture excepted) paler. Densely clothed (except for some conspicuously glabrous spaces) with short stramineous and white pubescence. Long. 30 mm.

Hab.—New South Wales: Narara.

acutely bispinose at apex, but not so strongly as in male, with remnants of feebly elevated lines and small pustules tending to form lines; basal ⅔ coarsely and conspicuously punctate, apical ⅓ almost impunctate. *Legs* moderately stout but not very long.

The clothing on the head is dense, sides in front of eyes, clypeus, and under surface are more sparsely clothed; the prothorax is widely glabrous along middle, widest behind, the pubescence on each side of the glabrous space not margined with white; the pubescence on the side is buff, and there is no white line; the scutellum is pilose in the centre and there is no white pubescence on the suture or any glabrous area, the whole of the elytra is densely and uniformly clothed with buff pubescence, there is no nitid area at apex of elytra; the spines are black; on the under surface the clothing is reddish-buff.

Dark piceo-castaneous. Densely clothed (except for area on thorax) with coarse buff pubescence. Long. 25 mm.

Hab.—Queensland: Imbil (A. R. Brimblecombe).

Genus Rhinophthalmus Thomson, 1860.

Rhinophthalmus hyalinatus sp. nov. (Figure 5.)

Slender, hyaline, creamy, with two transverse brown fasciae on elytra, and a lateral longitudinal line on prothorax and muzzle. *Head* relatively broad; muzzle stout, twice as long as broad; frons depressed, a narrow impressed median line extending from between antennary tubercles to ⅓ length of muzzle; muzzle coarsely and sparsely punctate; a lateral line of coarse pubescence along upper limits of lateral brown muzzle stripe. *Antennae* slender, pale yellow, considerably longer than body (apex of seventh joint just reaching extremity of elytra); basal joint elongate, lightly clavate, impunctate, subnitid; joints 2, 5–9 approximately equal; joints 3 and 10 shorter, approximately equal; 11 much shorter and narrowly tapering; 2–11 sparsely pilose. *Prothorax* elongate cylindrical, tapering anteriorly, hyaline, sparsely and irregularly punctate, strongly marginate anteriorly and posteriorly. Scutellum triangular, dark brown. *Elytra* narrow, wider than prothorax at base, slightly constricted before middle, tapering to apices; apices acutely rounded, unarmed; hyaline, subnitid, slightly shagreened at apex, not costate, a broad brown transverse fascia about middle, darkest on front border, not quite reaching lateral margin except on anterior limits, anterior border running obliquely inwards from just behind shoulder to suture; hind border straight; posterior brown patch extending along suture to apex and not reaching lateral margin except at apices,

which are entirely dark; lateral margin narrowly marginate. *Legs* pale yellow, very long and slender, sparsely pilose; femora slightly thickened apically; tibiae linear, slender; tarsi very slender and elongate. *Under surface* dark chocolate-brown, pruinose. Long. 17 mm.; lat. 3 mm.

Hab.—Queensland: Bunya Mts. (N. Geary), 29 January 1940. Holotype (unique) in Australian Museum.

A very distinct species, close to *R. nasutus* Newman, but readily distinguished by its non-pubescent hyaline appearance and brown fasciae.

Rhinophthalmus parvus sp. nov. (Figure 6.)

♀. Very slender, head and prothorax ferruginous, elytra bronze-brown with longitudinal pale costae. *Head* broad, muzzle relatively short, about 1¼ times length of head; apex of head and muzzle finely and closely punctate. *Antennae* very slender, dark brown, considerably longer than body; basal joint elongate, rather strongly swollen apically, subnitid; joint 3 slightly shorter than 4; 5–9 equal, longer than 4; 10 shorter than 9; 11 shorter than 10, tapered; 2–11 coarsely and closely pubescent. *Prothorax* elongate, cylindrical, constricted anteriorly on basal ⅓; basal ⅓ with indications of 2 weak tubercles; coarsely and somewhat closely punctate, with irregular nitid areas between punctures. *Elytra* coarsely punctate, pilose, slightly wider than prothorax at base, almost parallel-sided, tapering slightly to apex; apices pointed, unarmed; lateral margin and a broad raised longitudinal costa pale cream, neither reaching apex, discal costa shorter than margin, curving slightly inwards near base and then running parallel to sutural lateral margin strongly marginate, suture not marginate; apices naked, finely corrugate, broadly acute. *Legs* slender, dark brown, pilose; pedicels of costae yellowish; costae slightly expanded towards apices; tibiae slender, linear; tarsi very elongate, narrow. *Under surface* concolorous, with close fine pile. Long. 10 mm.; lat. 1·5 mm.

♂. Similar to female, smaller; femora not pale at base. Long. 7 mm.; lat. 1 mm.

Hab.—Queensland: Carnarvon Ranges (N. Geary), 14 December 1938. Holotype ♀ and allotype ♂ in Australian Museum.

The smallest member of the genus. Comes closest to *R. marginipennis* Fairmaire, but is very much more slender in form; muzzle much longer and narrower; prothorax relatively longer and narrower; elytral costae narrower, further from suture, strongly convergent at base instead of almost parallel; elytral apices finely corrugate, less acute; legs much longer and slenderer; all femora more pedunculate, and hind femora considerably longer.

Genus Syllitus Pascoe, 1859.

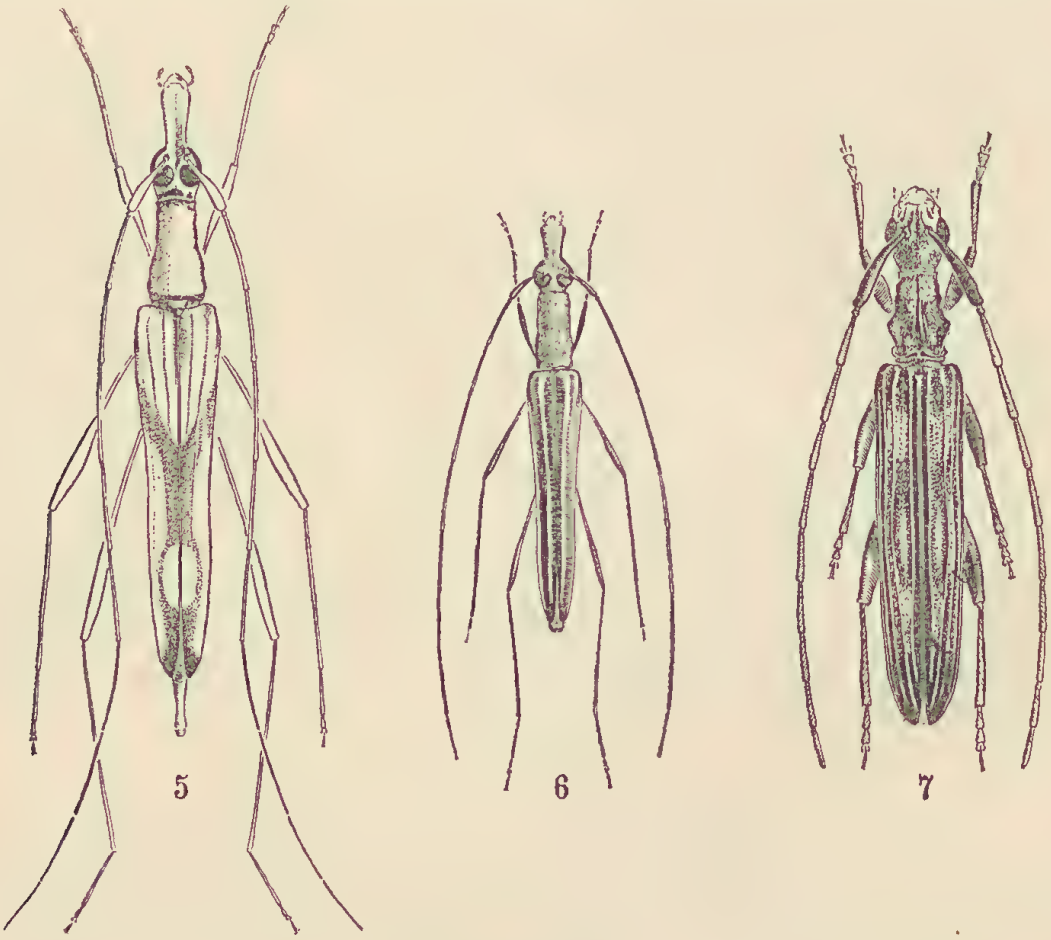
Syllitus bellulus sp. nov. (Figure 7.)

Robust, black, with 4 costae and lateral margin pale stramineous and an intricate pattern of stramineous lines and blotches. *Head* bright ferruginous-red clouded with brighter red on vertex and behind eyes; a relatively narrow deep impressed median line, not reaching to clypeal suture; finely and closely punctate, producing a shagreened appearance; eyes large, coarsely granulate; antennary tubercles medium; palpi slender, apical joint narrowly cylindrical. Antennae longer than body, slender, dull ferruginous, finely punctate, clothed with short erect pile; basal joint elongate, straight, externally somewhat swollen at apex, subnitid; joint 3 much shorter than 1, slightly longer than 4; joints 4–7 subequal; 7–8 subequal, shorter than 4; 9–11 subequal, shorter than 7; apical joint cylindrical, pointed, rather strongly curved. *Prothorax* elongate, cylindrical, more than twice as long as wide, anteriorly constricted, with a small lateral tubercle at about anterior ¼, strongly tuberculate laterally on basal ⅓; posterior border very strongly marginate, forming a sharp lateral ridge; disc with an elongate median nitid area or low glossy tubercle; dark ferruginous shaded with black, dark areas tending to form median and lateral longitudinal stripes. *Scutellum* small, rounded, with a black median line. *Elytra* narrow, parallel, rounding exteriorly to apex; 1st costa pale stramineous, parallel to suture, but converging at centre, not reaching apex; 2nd costa

pale stramineous, parallel to 1st, but diverging strongly at centre, and then inclining to but not quite reaching suture near apex; 3rd costa rising from shoulder, straight, generally parallel to second, not reaching apex, basally and apically stramineous; 4th costa narrow, very close and parallel to 3rd, joining lateral margin near apex; lateral margin stramineous throughout; base black, area between suture and first costa black; a large elongate black spot with a pale stramineous centre at middle between costae 1 and 2, where they diverge; irregular black markings at apex, remainder stramineous; interspaces between costae closely, finely and regularly punctate. *Legs*: femora black, finely punctate; tibiae dark ferruginous, pilose; tarsi paler, pilose. *Under surface* glabrous, subnitid, finely punctate, blackish. Long. 14 mm.

Hab.—Queensland: Injune, 2 November 1939. Holotype in Australian Museum.

One of the largest described species of *Syllitus*, comparable in size only with *heros* Blkb. and *acanthias* McKeown. In superficial appearance it comes close to the latter, but on examination is very distinct from all species known to me.



Figures 5-7.
5. *Rhinophthalmus hyalinatus*, n. sp. 6. *R. parvus*, n. sp. 7. *Syllitus bellulus*, n. sp.
[N. B. Adams, *del.*

Syllitus deustus Newman.

Entomologist, i, 1841, p. 95.

Slender, dark ferruginous; suture, lateral margin and 3 elytral costae pale. *Head* medium; antennary tubercles not prominent; median impressed line defined only on vertex; an oval subnitid depression extending from base of antennary tubercle to clypeal suture on each side; eyes large, prominent. *Antennae* stout, ferruginous; basal joint stout, elongate, considerably swollen to apex; joint 3 shorter than 1; 4–7 subequal, shorter than 3; 8–11 subequal, shorter than 4. *Prothorax* cylindrical, base broader than apex, not tuberculate, finely and closely punctate, laterally suffused with black. *Scutellum* small, scutiform. *Elytra* wider than prothorax at base; suture pale throughout; 1st costa pale, shorter than 2nd,

parallel to suture, curving slightly inwards to suture but not reaching apex; 2nd costa parallel to 1st, almost reaching apex, inclining to suture at extremity; 3rd costa parallel to 2nd, arising from shoulder, well defined over basal ⅓, but becoming narrower and somewhat obscure over remaining ⅔; lateral margin pale throughout. *Legs* dark ferruginous, femora blackish. *Under surface*: head and prothorax bright ferruginous-red, remainder black with fine close pubescence. Long. 8 mm.

Hab.—New South Wales: Bogan River (J. Armstrong); N.W. Victoria: Linga (F. E. Wilson col.).

In my revision of the genus *Syllitus* (Rec. Aust. Mus., xx, 2, 1937, p. 110) I stated that, in common with other workers on the group, I had never seen an insect that conformed with Newman's description of *S. deustus*. I have recently had the opportunity of examining three specimens which answer so closely to the exceedingly brief description of the 'lost' species that I have little hesitation in assigning them to *deustus*. It is on this assumption that I have redescribed the insect in some detail above.

Syllitus unistriatus sp. nov.

Slender, black; elytra with suture, 1 costa and lateral margin pale, and 3 costae concolorous. *Head* ferruginous, medium, glabrous, nitid, sparsely punctate; median line very fine; eyes medium; antennary tubercles large, prominent, approximate. *Antennae* black, coarsely punctate, shorter than body; basal joint long, slender, strongly curved; joint 3 shorter than 1, longer than 4; 4–11 subequal. *Prothorax* ferruginous clouded with black, stout, about twice as long as width at broadest point, strongly constricted on anterior half, swelling strongly just past half-way and contracting gradually to base; disc with 4 minute nitid tubercles arranged in a rectangle; a low nitid lateral tubercle at basal ¾. *Elytra* narrow, parallel, tapering regularly at apex; suture stramineous; 1st costa concolorous, narrow, running close to and parallel with suture, not quite reaching apex and curving sharply inwards to join 2nd costa; 2nd costa broad, stramineous, parallel to 1st and reaching apex; costa 3 narrow, concolorous, extending from shoulder, parallel to 2 and reaching to apex; costa 4 concolorous, extremely narrow, rising just outside shoulder, parallel to 3, reaching to apex; lateral margin strong, stramineous; interspaces between costae strongly and closely punctate, punctures between 1 and 2 finer and less regular than on remainder of elytra. *Legs*: 1st pair ferruginous; 2–3 black, finely punctate. Long. 6 mm.

Hab.—Queensland: Bunya Mts. (N. Geary), 4 January 1938. Holotype in Australian Museum.

Comes near *dubius* McKeown, but is very easily distinguished from that species by the pale suture, lateral margin and single pale costa, and very different sculpture. It is the only species known to me with but a single pale costa.

Genus Simocrysa Pascoe, 1871.

Simocrysa tricolor sp. nov.

Slender, head black, prothorax orange-red, elytra dark blue. *Head* broad, black, highly nitid, finely and regularly punctate, deeply excavated between antennary tubercles; frons broad, with a deeply impressed median line, somewhat concave with a strong lateral ridge running from antennary tubercles to insertion of mandibles; mandibles prominent, exposed; eyes large, prominent, finely granulate. *Antennae* as long as body, slender, basal joint elongate-clavate, dark metallic blue, highly nitid; joints 3, 4 and 6 equal; 4 and 7 equal, longer than 3; 8–11 shorter than 3, subequal; joints 3–9 basally yellow, apically blue; 10–11 entirely blue. *Prothorax* longer than wide, constricted anteriorly, nitid, disc with 5 smooth tubercles, 4 low and rounded, the central one small, acute; a lateral tubercle at about ⅔; anterior and posterior borders straight, broadly marginate, posterior strongly clouded with black. *Scutellum* minute, triangular. *Elytra* very coarsely reticulate-punctate, parallel-sided, apices acutely rounded; disc with 3 very narrow concolorous raised costae; junction of costae at apex forming a strongly and irregularly raised pustule or tubercle. *Legs* dark blue, slender; the 2 anterior pairs of femora slightly swollen; hind femora elongate, slightly swollen

to apex; tibiae linear, slender; tarsi narrow. *Under surface*: prothorax concolorous with upper surface; meso- and meta-thorax and abdominal segments dark blue, but with a reddish tinge, finely punctate. Long. 6 mm.; lat. 1 mm.

Hab.—New South Wales: Nepean River, Glenbrook Creek (A. Musgrave), 31 October, 1915. Holotype (unique) in Australian Museum.

A striking species, very distinct from *S. unicolor* Pascoe, the only other species in the genus, and quite unmistakable.

Genus Mecynopus Erichson, 1842.

Mecynopus annulicornis sp. nov.

Slender, fuscous varied with cream and red. *Head* black, nitid, broad, vertex full, domed, coarsely punctate, punctures widely spaced, closer on frons; frons clothed with sparse hairs; clypeal suture strongly procurved, deeply impressed; eyes large, prominent, finely granulate; antennary tubercles inconspicuous, strongly flattened basally. *Antennae* slender, considerably longer than body, base of 8th joint just reaching apex of elytra, dark fuliginous, apical $\frac{2}{3}$ of 9th joint and whole of 10th glistening white; coarsely punctate, clothed with dense concolorous pile; basal joint short, swollen; joints 3–4, 8–9 approximately equal; 5–6 equal, longer than 3; 7 longer than 5; 10 shorter than 3; 11 shorter, cylindrical. *Prothorax* broad, slightly narrower than elytra at shoulders, sides slightly curved, constricted anteriorly and posteriorly; disc bright red, irregular, with a highly nitid elongate low median tubercle; punctures large and sparse; anterior margin strongly marginate, coarsely and closely punctate, black; posterior margin lightly marginate, coarsely punctate, black; sides lightly rounded. *Scutellum* small, triangular. *Elytra* narrow, slightly constricted from below shoulder, very coarsely, deeply and closely punctate, dark fuscous with a longitudinal median costa of creamy-yellow extending to apex; apices broadly and strongly rounded from lateral margin, with a small tooth-like spine on suture. *Legs* long and slender. Anterior pair fuliginous; femora swollen, reddish at base, with sparse pile; tibiae slender, densely clothed with pile mixed with long hairs; tarsi stout, hairy. Middle pair: femora swollen, strongly reddish at base, pilose; tibiae strongly swollen (almost clavate) apically, with sparse hairs; tarsi short, stout, hairy. Posterior pair: femora slender, elongate, extending past apex of elytra, orange-yellow over basal $\frac{1}{3}$, with sparse hairs; tibiae very long, slender, wholly fuliginous, very hairy; tarsi long, slender, glistening white, apical joint and claws fuscous, hairy. *Under surface*: thorax densely and coarsely punctate, with scattered hairs; pleura with dense white clothing; abdominal segments reddish, subnitid, finely punctate, with a sparse clothing of scattered hairs. Long. 7 mm.; lat. 1·5 mm.

Hab.—New South Wales: Rope's Creek (type). Queensland: Mt. Coot-tha (H. Hacker), 8 November 1924; Mt. Tambourine (W. H. Davidson). Holotype in Australian Museum.

This beautiful little species appears to be somewhat variable; in the specimen from Mt. Coot-tha only the basal portion of the costa is yellow; in that from Mt. Tambourine (which may be the female) the elytra are wholly unicolorous and the prothorax entirely black.

This species is much smaller and of very different coloration to *M. cothurnatus* Er., and lacks the oval glassy spot of *M. semivitreus* Pasc. The white coloration of the two penultimate joints of the antennae gives the insect an appearance very different from any other member of the genus.

Genus Eroschema Pascoe, 1859.

Eroschema apicipenne sp. nov.

Slender, stramineous-yellow, apices of elytra and antennae black; legs varied. *Head* medium, narrower than prothorax at anterior margin, densely clothed with long yellow pile; eyes large, prominent, coarsely granulate; antennary tubercles full, prominent. *Antennae* shorter than body; basal joint stout, obconical; joint 3 as long as basal; 4 shorter than 3; 5 as long as 3; 6–11 subequal, slightly shorter than 5; joints 1–4 with erect hairs; 5–11 slender, tapering, pilose. *Prothorax* longer than broad,

expanded into stout lateral spines, clothed with dense yellow pile; disc tuberculate, strongly constricted before and (slightly less) behind; a black longitudinal stripe along side of prothorax passing over upper surface of lateral spine. *Scutellum* narrowly triangular (apparently), densely clothed with long erect pile obscuring shape. *Elytra* narrow, parallel, apices rounding to a blunt sutural angle; disc with 3 concolorous raised, nitid costae; interspaces shallowly reticulate-punctate; suture and lateral margin strongly marginate; basal third clothed with long yellow pile, then almost glabrous to apical ⅛ which is black, nitid; apices fringed with short black hairs. *Legs*: femora slightly thickened, 3rd longest, 1st and 2nd yellow, black at base and apex, 3rd wholly black; tibiae stout, black, with long golden pubescence towards and around apex; tarsi black, fringed with short yellow hairs. *Under surface* black, nitid. Long. 11 mm.; lat. 2·5 mm.

Hab.—Queensland, Port Denison. Holotype (unique) in Australian Museum.

Comes nearest to *E. affine* Pascoe, but differs from that species in the narrower and much less basally-expanded prothorax, the nitid black elytral apices, and the particoloured first and second femora.

Genus Chaodalis Pascoe, 1865.

Chaodalis taylori sp. nov.

♀. Robust, orange-yellow, a stripe on each side of prothorax, legs, antennae and under surface black. *Head* small, narrower than prothorax; eyes large, prominent, finely granulate; vertex with a narrowly triangular area of bright orange pile; area of frons between lower lobes of eyes and clypeal suture densely clothed with long, coarse, stramineous hair; antennary tubercles prominent, acute. *Antennae* much shorter than body; basal joint small, weak, obconical; joints 3–7 broadly expanded, cordate, flattened; 8–10 similar, very much narrower, decreasing in size; apical joint narrowly ovoid. *Prothorax* as long as broad, strongly constricted anteriorly, with a strong and broad tooth or spine; disc with a conspicuous raised median line and 2 small obtuse tubercles on discal edge above lateral tooth, the posterior the larger; centre of disc with a triangular area of close velvety orange pile, sides black, velvety. *Scutellum* triangular, with short pile. *Elytra* flattened and somewhat dilated posteriorly; each elytron with 4 weak longitudinal costae; lateral margin strongly marginate; base very finely and sparsely punctate; remainder apparently impunctate, clothed throughout with a very fine, close pubescence mixed with longer fine golden hairs, densest at base. *Legs* black, subnitid, sparsely pilose. *Under surface* black, finely and closely punctate throughout, with a narrow lunulate band of dull white pubescence on edge of each abdominal segment. Long. 18 mm.; lat. 6 mm.

♂. Smaller; antennae as long as body; joints more elongate, expanded on one side only of apex, decreasing progressively in width, wholly pubescent; joints 3–4 equal, shorter than 5; 5–11 subequal; centre of elytra rich dark brown with a yellow border around margin, broadest apically; under surface glabrous, lacking lunulate pubescent abdominal patches. Long. 13 mm.; lat. 4 mm.

Hab.—New South Wales: Blue Mountains (F. H. Taylor). Queensland: National Park, Macpherson Range (A. Musgrave), December 1926. Holotype ♀ and allotype ♂ in Australian Museum.

I have seen a pair of this species taken *in cop.* in the late H. J. Carter's collection, so have no hesitation in associating the specimens before me as sexes.

Differs from *C. macleayi* Pascoe in the strongly marked colour pattern of the prothorax, which completely reverses that of Pascoe's species, and in the much coarser sculpture of the elytra.

Genus Pytheus Newman, 1840.

Pytheus castaneus sp. nov.

Slender, chestnut-brown, costae pale, head, antennae, and legs black. *Head* small, narrower than prothorax; vertex coarsely and sparsely punctate; frons with very large shallow contiguous punctures; cheeks prominent, finely and closely punctate; eyes

small, finely granulate; antennary tubercles scarcely developed. *Antennae* shorter than body, not passing beyond hind coxae, black; basal joint obconical, nitid, sparsely punctate, with erect hairs; joints 3–4 short, rounded, nitid, with erect hairs, equal; 5–6 longer than 3, equal; 7 longer than 5, 8–11 subequal, flattened, progressively decreasing in width; apical joint obtusely pointed; joints 5–11 dull, pilose. *Prothorax* elongate, cylindrical, sides almost straight, marginate. *Scutellum* narrowly triangular, finely punctate. *Elytra* narrow, regularly tapering to apex; apices rounded; disc coarsely reticulate-punctate; 2 raised costae on each elytron, the inner rising inside prothoracic breadth, curving slightly outwards towards shoulders and then continuing straight to apex where it curves sharply inwards and joins suture; the 2nd costa rising at shoulder and continuing almost parallel to lateral margin which it joins at apex; suture very narrowly marginate, concolorous; 1st costa rich stramineus clouded with black about ¾; lateral margin widely marginate, concolorous; colour on disc darkest along sutural area; sparsely clothed with fine erect hairs throughout. *Legs* black, femora clavate, glabrous, nitid; tibiae short, stout, with erect hairs; tarsi apically wide. *Under surface* dark brown, subnitid, finely punctate. Long. 8 mm.; lat. 2 mm.

Hab.—Queensland: Bunya Mts. (N. Geary), 4 January 1938. Holotype (unique) in Australian Museum.

Nearest in form and elytral sculpture to *P. rugosus* Newman, but differs markedly in the shape and sculpture of the prothorax, rounded elytral apices, and colour pattern.

Genus Titurius Pascoe, 1875.

Titurius intonsodorsalis sp. nov.

Slender, light-brown with purplish lustre near base, head and prothorax black. *Head* large and broad, as wide as prothorax, coarsely rugoso-punctate; eyes small, finely granulate, deeply emarginate; antennary tubercles small, inconspicuous. *Antennae* dark brown, short, reaching to hind coxae, stout; basal joint short, obconical; joint 2 relatively large, rounded; joints 3–4 equal, shorter than 5; joints 6–7 equal, shorter than 5, slightly longer than 3; joints 8–11 subequal, shorter than 6; 6–11 thickening progressively to apex, which is broad and rounded. *Prothorax* regularly oval, sides evenly rounded, expanded very slightly at basal ⅓, nitid, coarsely rugoso-punctate, laterally clothed with dense felted grey pile. *Elytra* narrow, parallel-sided, slightly constricted about basal ¼, apices rounded; coarsely and regularly punctate over apical ¾, punctures near suture tending to form regular parallel lines; subnitid, glabrous with the exception of a line of dense grey pile along suture. *Legs* dark ferruginous; first and second femora strongly clavate, hind longer, swelling gradually to apex, nitid; tibiae stout, linear, 1st and 2nd with short scattered hairs, hind not apically spined; tarsi narrow. *Under surface* dark brown, finely punctate, nitid, laterally clothed with dense grey pile throughout. Long. 8 mm.; lat. 1·5 mm.

Hab.—Queensland: Brisbane. Holotype (unique) in Australian Museum.

I believe the specimen to be a female. It differs from *T. calcaratus* Pascoe in the form of the prothorax, more slender build, more constricted elytra, together with the sparser and less regular puncturation and the stouter antennae. Pascoe suggests that the apical spine on the tibia in *T. calcaratus* might be a sexual character, but it is present in both sexes of that and the following species.

Titurius salebrosus sp. nov.

♀. Slender, red-brown shading to blackish near apex; head and prothorax black. *Head* relatively large, constricted basally, narrower than prothorax, nitid, coarsely and closely punctate; antennary tubercles low, transverse. *Antennae* shorter than body, reaching behind hind coxae, black; basal joint obconical, finely punctate, nitid, with fine erect hairs; joints 3–4 equal, shorter than 5; 5–6 equal; 7 shorter than 5, longer than 3; 8–11 equal, as long as 3; 6–11 broadening progressively; 2–11 finely and closely punctate, dull, pilose. *Prothorax* very coarsely and irregularly punctate, with fine erect hairs; longer than wide, strongly tuberculate laterally; constricted strongly behind anterior margin; posterior area slightly constricted, dorsally depressed; disc with several

obscure tubercles; anterior border widely marginate, posterior immarginate. *Scutellum* small, rounded, with grey pile. *Elytra* narrow parallel-sided, very slightly constricted about middle; apices rounded; disc with an obscure raised costa running from shoulder almost to apex; interspace between suture and costa regularly and deeply seriate-punctate, between costa and lateral declivity coarsely and regularly punctate, laterally finely and closely punctate; a longitudinal stripe of pale grey pile along suture; remainder of elytra with sparse fine hairs. *Legs* dark red-brown; 1st and 2nd coxae short, clavate, finely punctate; 3rd long, slender, expanding gradually to apex, coarsely and sparsely punctate with fine erect hairs; hind tibia with a long, projecting apical spine; 1st and 2nd tibiae shorter than 3rd, punctate, with erect hairs, densest near apex; tarsi narrow, black. *Under surface* concolorous, laterally pilose throughout. Long. 9 mm.; lat. 2 mm.

♂. Similar to female; antennae longer than body; joints 3–4 equal, shorter than 5; 5–11 subequal; prothoracic punctures sparser; hind tibiae apically spurred. Long. 6 mm.; lat. 1 (+) mm.

Hab.—New South Wales: Kurrajong (Masters), Hazelbrook (J. Armstrong). Holotype ♀ and allotype ♂ in Australian Museum.

Superficially close to the previous species, but differs in elytral sculpture, thoracic form and sculpture, antennae, etc.

Genus Pempsamacra Newman, 1838.

Pempsamacra carteri sp. nov.

♀. Slender, bright cinnamon-brown clouded with black. *Head* small, finely rugoso-punctate; eyes small, very finely granulate; antennary tubercles small, not prominent. *Antennae* not reaching to hind coxae; basal joint elongate-cylindrical, coarsely rugoso-punctate; joint 3 longer than 4, slightly longer than 5; 5 apically expanded on one side; 6–11 flattened and bilaterally expanded to form a broad club; 3–6 subnitid; 7–11 finely punctate. *Prothorax* narrow, slightly wider than head, coarsely rugoso-punctate, constricted anteriorly and posteriorly, sides evenly rounded; disc with 2 elongate, parallel, low tubercles, depressed between, and a strong longitudinal lateral ridge. *Elytra* narrow, broader than prothorax, parallel-sided, tapering to apices; apices narrowly rounded, sharply depressed dorsally; coarsely rugoso-punctate throughout, puncturation coarsest towards base; disc with 2 obscure raised longitudinal costae; no apparent adherent scales. *Scutellum* broadly triangular, surrounded by a pale nitid area on elytra extending backwards along suture for a short distance. *Legs* dark chestnut-brown; femora narrowly clavate, finely and closely punctate, with scattered silvery scales especially dense on inside; tibiae slender, finely punctate; tarsi narrow. *Under surface* sparsely clothed with small silvery scales largely concentrated towards sides of abdominal segments. Long. 9 mm.; lat. 2 mm.

♂. Similar to female, but smaller. Long. 7·5 mm.; lat. 2 (–) mm.

Hab.—S. Queensland: Wyberba (E. Sutton), on Paper-bark Tea Tree. Holotype ♀ and allotype ♂ in Australian Museum.

Somewhat similar in general appearance to *P. argentata* Pascoe, but entirely lacking the dense clothing of golden scales upon the elytra. There is no indication in a series of 5 specimens that this absence of adherent scales is due to abrasion or other cause, and appears to be normal. The form of the prothorax and absence of the dark elytral spots separate it from *P. tillides* Newman.

Named for the late H. J. Carter at Mr. Sutton's request.

Genus Nungena nov.

Slender medium sized insects. *Antennae* situated laterally in front of a deep transverse suture on frons and in advance of eyes; eyes finely granulose, almost or completely divided into two distinct parts; antennary tubercles very large, broad, strongly transverse, approximate. *Prothorax* strongly tuberculate on disc. *Elytra* parallel-sided, not costate, unarmed. *Legs*: femora clavate; tibiae stout; first joint of tarsi longer than 2–3 combined.

Genotype: the following species.

Nungena binocularis sp. nov. (Figure 8.)

Slender, pale, ferruginous, darker on head and prothorax. *Head* with sparse erect hairs, broad, short, rounded, constricted behind, a deep transverse depression or groove in front of eyes and behind antennary tubercles; median impressed line extending from this groove to clypeal suture; antennary tubercles very large, swollen, transverse, approximate; eyes small, finely granulate, each divided into 2 parts connected only by a fine black line (not faceted), the upper somewhat broadly comma-shaped, the lower round, a broad shallow depression between the two portions. *Antennae* slender, longer than body, dark ferruginous, coarsely punctate, with erect hairs or setae; basal joint elongate, cylindrical, swollen slightly to apex, slightly curved, attachment to tubercle extremely fine; joints 3–4 subequal, about same length as 1; 5 longer than 3; 6–7 subequal, as long as 3; 8–9 subequal, shorter than 3; 10 shorter than 8; terminal joint wanting. *Prothorax* longer than wide at broadest point; disc strongly swollen in 2 large rounded tubercles, separated by a deep median sulcus extending down over sides; strongly constricted anteriorly and posteriorly; sparsely punctate on tuberculate area, closely on constricted areas; subnitid with sparse erect hairs. *Scutellum* small, rounded. *Elytra* slightly wider than prothorax at broadest point, parallel-sided, rounding sharply to apex; apices narrowly rounded, unarmed; stramineous, darker on suture, lateral margin and apex, finely and sparsely punctate, punctures densest on base and lateral declivity. *Legs* ferruginous; femora irregularly clavate, sparsely punctate, glabrous; tibiae stout, densely and finely punctate with erect hairs; tarsi with 1st joint stout, elongate, cylindrical, 4 times length of 2, punctate, with erect hairs, joint 2 short, stout, punctate, claws slender. *Under surface* finely punctate; sterna with sparse recumbent pile; abdominal segments glabrous, black. Long. 8 mm.; lat. 1·5 (+) mm.

Hab.—Queensland: Condamine (N. Geary), 26 January 1939. Holotype (unique) in Australian Museum.

A very remarkable little species, of which I am unable to indicate the systematic position, except that it falls in the Cerambycinae. The only genus known to me in which the eyes are almost or entirely divided into two parts is *Tetraglenes* Newman, from the East Indies, with which the present species seems to have but remote affinity. It has, therefore, been considered necessary to erect a new genus for its reception. Even when examined under a high power of the microscope the extremely narrow black line, the only indication of connection between the lobes, appears wholly without facets. The antennary tubercles are completely separated from the eyes by the transverse frontal sulcus, and are so large and tumid that they completely cover the vertex of the head, and so transverse that the antennae appear to be situated laterally.

While this paper was in galley proof I received from my young friend Master Roy Pullen three further specimens of this remarkable species taken at Armidale, New South Wales, together with several branches infested with larvae. It is therefore possible to add further particulars. The holotype, described above, is a female. Another female in the series measures 8½ mm. The missing terminal joint of the antenna is slender and slightly curved, equal in length to 9 and longer than 10.

♂. Smaller and darker than ♀; antennae longer. Long. 7½ mm.

Hab.—Armidale, New South Wales, 6 May, 1942. Allotype in Australian Museum.

Host Plant: "Cypress Pine." The larval tunnels are broad and shallow, and situated immediately under the bark, but a few penetrate the wood of the branch—these are smaller and more circular.

Genus Stenellipsis Bates, 1874.

Stenellipsis cruciata Breuning.

This little species was originally described by Breuning with the somewhat wide locality of 'Queensland'. There are a number of specimens in the Museum collection with the undermentioned localities.

Hab.—New South Wales: Comboyne (H. J. Davidson), 1937; Clarence River (A. M. Lea). Queensland: Macpherson Range.

Stenellipsis spencei sp. nov.

Robust, piceus varied with buff pile. *Head* large, broad (as wide as prothorax), widely and shallowly concave between antennary tubercles; impressed median line very indefinite; eyes small, not prominent, deeply emarginate; frons with whitish pubescence; antennary tubercles low, transverse. *Antennae* stout, as long as body, dull ferruginous; basal joint clavate, notched at base on inner side; joints 3–4 subequal, longer than 1 (= 1 and 2 together); 5–11 progressively decreasing in length and thickness; 3–11 with a pale basal band. *Prothorax* longer than wide, cylindrical, slightly and regularly rounded on sides, very finely and closely punctate, densely pruinose with small irregular patches of a pale shade. *Elytra* wider than prothorax, gradually tapering, rounding to apex; apex acutely rounded; shoulders prominent; disk deeply and regularly punctate at base; base densely clothed with yellowish pile forming a low crest between suture and shoulder; a broad pilose fascia of simliar colour crossing elytron a little before apex; central area of disc pruinose with a purplish lustre varied with small linear whitish areas; disc strongly depressed behind pilose area at about ⅓. *Legs* brown; femora basally banded with yellow; front femora broadly clavate, middle slightly clavate, hind swollen. *Under surface* black, subnitid, finely punctate; 1st abdominal segment coarsely punctate. Long. 4 mm. Several specimens long. 2·5 mm. are possibly males, but do not differ save that the basal clothing is more extensive.

Hab.—New South Wales: Tuggerah (Dr. K. K. Spence), October 1934 (type); Lane Cove (Dr. K. K. Spence), October 1934; Ulong, E. Dorrigo (W. Heron); Galston (W. W. Froggatt); Gosford (W. W. Froggatt); and Sydney. Holotype in Australian Museum.

Easily distinguished from *S. cruciata* Breuning by the absence of the pale coloured X mark on the elytra which is replaced by a pale fascia. The more rugose appearance will also aid in identification. A large series is very consistent in coloration, but in some specimens the legs are wholly dark.

Named in honour of Dr. K. K. Spence, of Sydney, to whose skill as a collector, especially of small forms, many Australian workers are indebted.

Genus Karadinia nov.

Large, robust insects. *Head* medium, eyes finely granulate, not strongly emarginate; cheeks prominent; antennary tubercles transverse. *Antennae* stout; basal joint elongate, broadening regularly to apex; joint 3 longest, remainder progressively decreasing; joint 6 with stout apical spine. *Thorax* strongly transverse, tuberculate on disc, laterally spined. *Elytra* broad, parallel-sided. *Legs*: femora strongly clavate with a spine-like structure, welded throughout its length to extreme base of petiole.

Genotype: the following species.

Karadinia nubila sp. nov. (Figure 9.)

Robust, fuliginous varied with buff and small black spots ringed with white. *Head* medium, narrower than prothorax; an impressed median line extending from base to clypeal suture; clypeal suture irregular, marginate; cheeks prominent; vertex impunctate save for a few large punctures around eyes; frons with a few small scattered punctures; eyes medium, finely granulate, not strongly marginate, fringed (especially anteriorly) with buff pile; antennary tubercles stout, transverse, prominent. *Antennae* stout, slightly longer than body, brown, pubescent, banded except for apical joint with white about middle of each joint; basal joint elongate, broadening regularly to apex, sparsely punctured; joint 3 longer than basal; joint 4 shorter than 3 (about ⅔ length); remaining joints progressively decreasing in length; joint 6 with a stout nitid black apical spine projecting almost at right angles. *Prothorax* strongly transverse (breadth of prothorax including lateral spines slightly greater than length of head and prothorax combined); a broad, acutely pointed lateral spine at middle with a small obtuse tubercle above and somewhat in front of it; disc strongly and irregularly tuberculate, with large scattered punctures; central basal tubercle on this area high, smooth, regular elongate-ovoid; thoracic margins almost straight, anterior slightly,

posterior strongly marginate; thorax constricted before and behind tuberculate area, with many large irregularly dispersed punctures. *Scutellum* broadly costate, truncate behind, pilose. *Elytra* much broader than prothorax at widest, parallel-sided, somewhat roundly truncate at apex; shoulders prominent; base sparsely punctate and with small tubercles forming 2 short longitudinal ridges between shoulder and suture; an irregular shallow depression at about $\frac{1}{3}$, remainder of elytra smooth, densely pilose and (apparently) almost or quite impunctate; extreme base dark brown with a few large punctures narrowly ringed with white; behind this an irregular wavy black transverse band (broken at centre), narrowly and somewhat irregularly margined with white behind; behind this again and extending to apex is a large irregular area of buff pile clouded with brown crossed at about $\frac{3}{4}$ by a zig-zag transverse black line and a large lateral black patch margined posteriorly with white; this area is liberally sprinkled with small, round, black pilose spots, each narrowly margined with white. *Legs* blackish-brown; femora stout, broadly clavate, petiole slender, elongate, lightly marbled with grey pubescence, subnitid, petiole with a black, nitid, spine-like structure slightly projecting, but firmly welded throughout its length to the extreme base of shaft; tibiae stout, banded centrally with greyish-white pubescence, fore-tibiae somewhat expanded apically, sparsely punctate; tarsi broad, black, margined with black bristles and white hairs, claws black. *Under surface* black, subnitid, with a sparse greyish pubescence and a few spots of buff pile; abdominal segments subnitid, with sparse greyish pubescence (especially laterally) and a few small marginal spots of buff pile on apical segments. Long. 22 mm.; lat. 8 mm.

Hab.—Queensland: Carnarvon Ranges (N. Geary), 16 January 1940. Holotype (unique) in Australian Museum.

Host plant.—Mr. Geary informs me that this insect was bred from a pupa found in the branch of a wattle (*Acacia* sp.); a second pupa died.

Genus Ancita Thomson, 1864.

Ancita albopicta sp. nov. (Figure 10.)

Robust, piceous, densely clothed with close dark-ferruginous pile varied on prothorax and elytra with patches of very dense snowy-white pile; antennae banded with white. *Head* broad, as wide as prothorax exclusive of lateral spines; vertex full, strongly convex, finely and closely punctate, densely pilose; an obscure median line extending from apex to clypeal suture; clypeal suture irregular, recurved, widely marginate; eyes small, granulation moderately fine, cheeks not prominent; frons coarsely pilose with large scattered punctures; antennary tubercles strongly transverse, moderately prominent. *Antennae* longer than body, stout, pilose, fringed beneath with long hairs; basal joint stout, regularly obovate, finely and closely punctate; joint 3 long (about $\frac{1}{3}$ longer than 4), remaining joints progressively decreasing in length; apical joint short, slender; joints, 4, 6, 8 and 10 basally banded with white. *Prothorax* transverse, wider than long, acutely spined laterally; disc naked, tuberculate, nitid, lateral tubercles low, densely and coarsely punctate, median rather high and glossy; a narrow median pubescent stripe extending from base to apex, dividing at centre to surround base of median tubercle, anterior portion buff, posterior snowy-white; a broad longitudinal lateral curved stripe above lateral spine; sides anteriorly to lateral spine coarsely punctate; anterior thoracic border sinuate, not marginate, posterior sinuate, marginate. *Scutellum* scutate, broadly rounded behind, with coarse grey pubescence and a broad longitudinal naked line. *Elytra* broad, considerably wider than prothorax, gradually tapering; apices rounded, shoulders prominent, coarsely pubescent with naked areas of derm appearing as irregular spots and patches; base coarsely rugose, punctate central area with large, sparse punctures concentrated (apparently) mainly on naked areas; apical $\frac{1}{4}$ almost impunctate; a short diagonal line inclined to suture about basal $\frac{1}{3}$, a large irregular patch about centre not reaching suture or lateral margin, and a small cordate spot near apex, all of dense, velvety, snowy-white pile. *Legs* stout, brown, with long whitish pubescence; femora strongly clavate. *Under surface*: sterna coarsely and sparsely punctate, with coarse mixed grey and brown pubescence; abdominal segments

with close grey and brown pile, a lateral longitudinal white pilose stripe; apical segment with a median white pilose area. Long. 15 mm.; lat. 6 mm.

Hab.—Queensland: Rockhampton. Holotype (unique) in Australian Museum.

A very large robust species which, by reason of its very distinct colour-pattern of brown and white pubescence, cannot be confused with any of its described congenors. The nitid areas on the elytra are not, I think, due to abrasion as they are too regular in form and distribution.

Genus Temnosternus White, 1855.

Temnosternus catulus sp. nov.

Robust, black clothed with greenish pile varied with yellow. *Head* not wider than prothorax at anterior margin; apex sparsely and coarsely punctate, with a short impressed median line; frons and cheeks clothed with dense yellow pile; eyes large, emarginate, coarsely granulate, with a narrow yellow pilose edging; antennary tubercles small, inconspicuous. *Antennae* longer than body, stout, finely punctate, pruinose with a sparse fringe of black hairs beneath; basal joint elongate, cylindrical, centrally swollen, very closely and finely punctate, sparsely pilose; joint 4 longer than 3; 5 shorter than 3; 5–11 becoming progressively shorter. *Prothorax* considerably broader than long, wider at base than apex, sides regularly curved, with an acute spine about half-way; anteriorly and posteriorly marginate; disc with a broad, naked, subnitid longitudinal median area with, on either side, a broad stripe of dense yellow pile, and an almost naked stripe on side of thorax embracing lateral spine; median and lateral naked areas with very large sparse punctures. *Scutellum* small, truncate behind. *Elytra* considerably wider at base than prothorax at widest, tapering sharply to apex; apices obliquely truncate, forming a blunt lateral spine; clothed with thin greenish pile with irregular patches of dense yellow pile placed rather laterally, largest near apex, but a few very small yellow spots close to suture near middle; disc coarsely and sparsely punctate over basal $\frac{3}{4}$; a broad, raised, longitudinal costa extending from centre of base to about $\frac{3}{4}$, a row of small shining tubercles extends costa across base almost to scutellum. *Legs* brown, stout, femora clavate, nitid, sparsely pilose; tibiae pilose, hairy at apex; tarsi broad, hairy. *Under surface* wholly clothed with dense buff pile. Long. 11 mm.; lat. 4 mm.

Hab.—Queensland: Southport (H. Hacker), 26 January 1939; Tambourine Mt. (H. Hacker). New South Wales: Tweed River. Holotype in Queensland Museum.

Smaller specimens measuring 9·5 mm. in length and 3 mm. broad may be males, but I can detect no differences in structure or clothing. The elytral costae in some specimens are naked and shining, a condition due possibly to abrasion.

A distinctive species coming possibly close to *T. vitulus* Pasc., but readily separated from that insect by its elytral clothing and the elytral costae.

Temnosternus flavolineatus sp. nov.

♀. Slender, dark ferruginous, clothed with close light-brown pubescence. *Head* relatively broad, but narrower than anterior border of prothorax, apex with a shallow impressed median line, clothed with brown pile, antennary bases prominent, entire frons and antennary bases densely clothed with yellow-buff pile, cheeks and clypeus with thinner brown pile. *Antennae* slender, slightly longer than body, clothed with sparse, fine pubescence; basal joint swollen tending to clavate; joint 4 scarcely longer than 3; 5–11 equal, shorter than 3; joints 3–10 sparsely fringed beneath with black hairs. *Prothorax* about $\frac{1}{3}$ broader than long, approximately rectangular, angles not prominent, strongly marginate on anterior and posterior borders, a stout lateral spine about middle, disc coarsely punctate; a median longitudinal area of naked reddish-brown derm, on each side of this an elongate ovoid patch of bright golden-yellow pubescence; remainder of disc with sparse brown pile, lateral angles coarsely punctate. *Scutellum* scutiform with an impressed median line, lightly clothed with brown pubescence. *Elytra* gradually tapering to apical $\frac{1}{3}$, abruptly to apex, broader at base

than prothorax at widest, with sparse but evenly distributed punctures throughout, a few small shining black tubercles near scutellum, a tendency to a raised costa parallel to but at some distance from suture, but converging towards it slightly at apical ⅓, then diverging; lateral margin wholly and suture apically marginate; apices diagonally truncate producing a broad external point; elytra clothed throughout with close brown pubescence varied with narrow linear areas of dense golden-yellow pubescence; taking the pattern over both elytra, these yellow lines are: a somewhat roughly O-shaped marking at base surrounding, but distant from, scutellum, on its lower portion the line divides and then reunites so as to form two small lightly pubescent dark areas within the circumference of the circle; at centre of elytra an X-shaped mark with upper limbs wider than lower; at apex two figures like opposed but broken F's, their stems being pale cream in colour and extending to extreme apical point. *Legs* stout, brown, clothed with sparse greyish pile; tibiae encircled with long golden hairs at apex. *Lower surface*: sterna with large patches of golden-yellow pubescence on sides; abdominal segments, with the exception of terminal, each with two large yellow densely pubescent patches margined with close grey-brown pile. Long. 10·5 mm.; lat. 3 mm. (type). Another female long. 12 mm.; lat. 5·5 mm.

♂. Similar to female but smaller and more slender; antennae longer than body, eyes larger; anterior angles of prothorax more prominent, flattened and slightly upturned; yellow markings differing slightly; basal more shield-shaped with procurved arc connecting sides. Area extending from elytral base to lower limbs of X mark (including lateral areas) coarsely punctate; apical area impunctate. Long. 8 mm.; lat. 2 mm.

Hab.—Queensland: Mt. Glorious (H. Hacker), 8 September 1937 (type); Mt. Gipps (H. Hacker), January 1930; Kuranda (A. J. Turner), 30 September 1929. Holotype ♀ and allotype ♂ in Queensland Museum.

This insect bears little resemblance to any other described species.

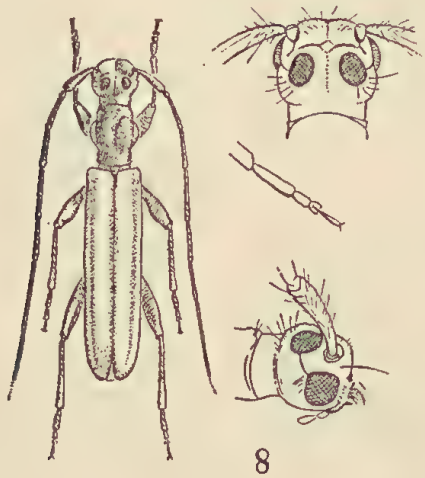
Temnosternus niveoscriptus sp. nov. (Figure 11.)

♂. Moderately robust, pitchy, clothed with dense buff pile varied with white linear pattern. *Head* narrower than anterior border of prothorax, finely and irregularly punctate on exposed derm; a broad area, bisected by a deep, narrow, median line extending from prothoracic margin across vertex, laterally contiguous with eyes, covering antennary tubercles, and continuing over frons to clypeal suture; clothed with pale yellow-buff pile; area behind eyes naked, finely and sparsely punctate, subnitid; a lateral longitudinal pale stripe below eye. *Antennae* slender, reaching to extremity of elytra; basal joint clavate, clothed with fine sparse pubescence; remaining joints finely pubescent; joints 2–9 fringed beneath with sparse black hairs; joint 3 ⅔ length of 4; 5–11 equal, each about half length of 3. *Prothorax* roughly rectangular, broader than long; anterior angles strongly produced, flattened, slightly upturned, tipped with black, nitid; a stout and acute lateral spine at middle; disc with a broad naked median longitudinal line, the derm pitchy, nitid; on either side of this a broad longitudinal band of light buff; between this and anterior angles a darker area with coarse scattered punctures showing through pile; on posterior margin of this area an isosceles triangle of naked derm with a few large punctures; sides with bright buff pubescence; a narrow longitudinal area extending from below anterior angle with many minute glossy tubercles. *Scutellum* truncate-triangular, clothed with buff pile; 2 naked patches near centre. *Elytra* broader than prothorax, parallel-sided to ¾ length, where they taper sharply to apex; apices diagonally truncate; the whole of the elytra densely clothed with buff pile marked with linear lateral markings of dense snowy-white pile; these markings are (on right elytron—reversed on left): a short longitudinal stripe on line extending from anterior margin to about ⅛ towards centre of elytron; a curved linear marking extending from lateral flexure at about ⅓ and extending towards, but not reaching, suture at about ½ elytral length, widest laterally, tapering towards suture; an F-shaped mark (or coalesced marks) extending over most of apical ⅓; basal ⅛ of elytron with numerous glossy-black, irregularly dispersed tubercles; remainder of elytron with sparse, large, black punctures each surrounded by a naked black nitid area mainly

concentrated in middle of elytron, but tending to form lines on suture and along lateral flexure, smaller punctures along lateral margin; a strong longitudinal raised costa nearly parallel to but somewhat distant from suture extending from basal white line almost to apex; between this and lateral margin another less distinct and broadly rounded raised costa reaching to about $\frac{2}{3}$. *Legs* clothed with sparse buff pubescence; femora somewhat clavate. *Under surface* densely clothed with bright buff pile with a central and two lateral longitudinal dark brown, subnitid, longitudinal stripes extending from base of abdomen to anterior margin of terminal abdominal segment; abdominal segments with scattered large black punctures. Long. 13 mm.

Hab.—Queensland: Mt. Gipps (H. Hacker), 20 April 1930. Holotype (unique) in Queensland Museum.

In colour and pattern this insect is very distinctive and bears no resemblance to any described Australian species.



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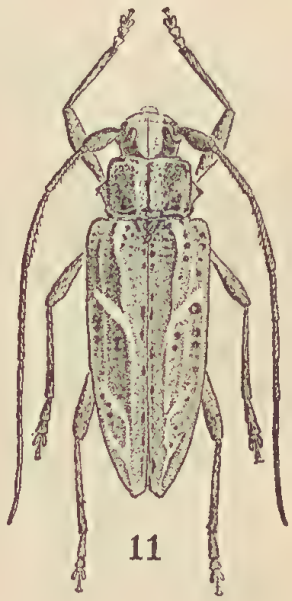

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Figures 8-11.

8. *Nungena binocularis*, n. sp. 9. *Karadinia nubila*, n. sp. 10. *Ancita albopicta*, n. sp. 11. *Temnosternus niveoscriptus*, n. sp.

[N. B. Adams, *del.*

Temnosternus quadrituberculatus sp. nov.

Robust, dark brown densely clothed with close fuscous pile varied with pale fawn. *Head* much narrower than prothorax; a broad band of pale fawn silky pubescence extending from base to (and including) clypeus and laterally to eyes and interior faces of antennary tubercles, pubescent band divided by a naked median longitudinal line from base to clypeal suture with a small widened area at junction with prothorax; vertex with 4 or 5 large nitid punctures, angulate between antennary bases; frons depressed, with a few large punctures revealing the nitid derm beneath; sides of head dark brown, pilose; antennary tubercles stout, prominent, flattened on inner faces; eyes relatively small, finely granulate. Antennae as long as body, brown, lightly pubescent; joints 3–9 sparsely fringed with black hairs beneath; joints slightly greyish basally; basal joint stout, clavate; joint 3 equal to 4; remaining joints much shorter, approximately equal. *Prothorax* strongly transverse with a stout lateral spine about middle, above this and between it and anterior margin a strong obtuse tubercle on edge of disc; anterior border narrowly, posterior widely marginate; disc with a strongly raised longitudinal median line, highest in centre, and with 2 separated naked areas of nitid derm; centrally depressed on either side of median line, depressions with a few large punctures, sides coarsely and rugosely punctate; a broad longitudinal band of pale fawn pubescence along centre of disc (continuing that on head) and extending narrowly along anterior margin; sides brown with a narrow longitudinal lateral fawn stripe crossing under surface of lateral spine. *Scutellum* broadly cordate, rounded behind, clothed with dense fawn pubescence and a closely defined nitid black longitudinal median line. *Elytra* broad (as wide as greatest prothoracic width), tapering gradually to apex; apices obliquely truncate, forming an exterior angle; disc with a raised nitid black costa running roughly parallel to suture, but converging sharply towards it at about ¼ length and again less strongly at about ¾, just beyond this point it junctions with a less distinctly defined lateral costa arising at about ⅓ and becoming almost obsolete beyond junction; disc with sparse large punctures, strongest and most numerous basally and laterally; suture and lateral margin strongly marginate, suture with a single row of large shallow black punctures; area along suture with patches of fawn pile, basal and central broadly diamond-shaped, the apical irregularly narrower. *Legs* light-brown, pilose; femora with a pale band before apex; tibiae with long white hairs apically; tarsi broad, with long pale hairs. *Under surface* densely clothed with close, pale pile; centre of abdominal segments castaneous, lateral margins lightly marked with the same tint. Long. 15 mm.; lat. 5 mm.

Hab.—Queensland: Imbil (A. R. Brimblecome), 1938. Holotype ♀ in Queensland Museum.

Comes close to the preceding species, but differs strongly in the elytral costae, colour and pattern, and in the abdominal clothing and the tuberculate prothorax. A very distinct species, unlikely to be confused with any other.

Temnosternus undulatus sp. nov.

Moderately robust, derm black, densely clothed with light brown pile varied with zig-zag lines and patches of pale yellow-buff. *Head* relatively narrow, with a broad longitudinal band of dense dull yellowish pile extending from base to (and covering) clypeus and laterally clothing interior planes of antennary tubercles, divided by a distinct naked longitudinal line not reaching to clypeal suture; sides brown; apex with two irregular lines of large punctures extending over frons; antennary tubercles not prominent. *Antennae* as long as body, light brown, sparsely pilose; joints 3–9 with scattered long black hairs beneath; basal joint narrowly clavate; joints 3–4 equal; 5 much shorter than 4, longer than 6; remaining joints becoming progressively shorter; a tendency to a pale ring basally and apically on each joint. *Prothorax* transverse, with a strong, slightly upturned lateral spine about middle; anterior discal angles blunt, with a short, deep impressed groove running backwards from each; anterior and posterior borders narrowly marginate; a deep impressed transverse groove or fold running parallel with and in front of posterior margin; a broad longitudinal band

of dense yellow pile with a naked longitudinal median line on centre of disc (continuous with that of head); sides brown with 2 narrow lateral pale stripes separated by lateral spine; disc with 2 shallow depressed areas, each with 5–6 large punctures; sides coarsely rugoso-punctate, especially towards antenior margin. *Scutellum* broadly and shallowly cordate, densely clothed with yellow pile, a nitid black median line not reaching to apex. Elytra slightly broader than prothorax including lateral spines, tapering gradually to apex; apices concave, truncate, forming an acute external angle; raised costa almost obsolete and conspicuous only (possibly due to abrasion) at ¼ where it approaches the suture slightly; suture and lateral margin narrowly marginate; coarsely and sparsely punctured throughout, but especially strongly at base; a few small glossy tubercles on shoulder; clothed throughout with close light-brown pile varied with intricate zig-zag linear markings and irregular patches of pale yellow-fawn pile, especially at ⅓, ⅔, and just before apex. *Legs* dark brown; femora with a pale ring at base and near apex; tibiae narrow with a pale ring towards apex; tarsi narrow, with sparse pale hairs. *Under surface* clothed with pale buff pubescence, with small scattered brown spots; abdominal segments (except apical) brown and nitid in centre with a small lateral dark area on each segment. Long. 15 mm.; lat. 4 mm.

Hab.—Queensland: Cairns. Holotype in Australian Museum.

Superficially very close to the preceding species, but easily separated from it by the absence of the strong anterior discal tubercles, its distinct pattern of intricate zig-zag lines and other features.

Genus **Penthea** Castelneau, 1840.

Penthea lichenosus sp. nov.

♀. Robust, brown, varied with black and white, densely pilose. *Head* broad, deeply excavated between antennary tubercles, densely clothed with dark brown pile varied with cinnamon and speckled with black; median line narrow, extending from apex to to clypeal suture, clearly defined throughout; eyes medium, finely granulate; antennary tubercles prominent, transverse. *Antennae* shorter than body, stout, black, sparsely pilose, subnitid; joints ringed with sparse greyish pubescence; basal joint obconical; joints 3–4 approximately equal; remainder progressively decreasing. *Prothorax* broad, as wide as long; lateral post-apical spine stout, above and slightly behind (on edge of lateral declivity) a smaller spine-like tubercle; disc swollen, somewhat irregular, coarsely and sparsely punctate, densely clothed with close pile, dark brown varied and mottled with cinnamon, black and grey, the latter forming 2 parallel longitudinal pale stripes (1 on either side of median line) and an irregular pale area on side. *Elytra* considerably wider than prothorax, shoulders prominent, apices broadly rounded; clothed with dense, short pile, dark brown varied with bright cinnamon and sprinkled with small rounded black spots; at basal ¼ a light cinnamon area crosses the elytron forming a pale band, on this is an irregular lateral white spot, several small white patches and a 3-shaped sutural white mark (reversed on left elytron); on apical ⅓ 2 irregular discal white markings with black spots in the centre, and a sutural mark behind. *Legs* stout, clothed with grey pile and mottled with black. *Under surface* densely clothed with long grey and cinnamon pile mottled with black. Long. 15 mm.; lat. 5 mm.

♂. Similar to female, but smaller; antennae slightly longer than body. Long. 13 mm.; lat. 5 (–) mm.

Hab.—Queensland: Coen River (W. D. Dodd). Holotype ♀ and allotype ♂ in Australian Museum.

A small species easily distinguished by its striking and distinctive elytral pattern and structural characters.

Genus **Corrhenes** Pascoe, 1865.

Corrhenes cordata sp. nov.

Robust, fuscous, with a cordate black nitid glabrous patch at base of elytra. *Head* relatively small (narrower than prothorax), densely clothed with pale fuscous pile; antennary tubercles inconspicuous, transverse; eyes moderate, finely granulate. *Antennae*

shorter than body, clothed with fuscous pile tending to form apical rings on antennal joints, fringed with sparse long hairs beneath; joints 3–4 curved, subequal; joint 5 shorter; 5–11 progressively decreasing in length. *Prothorax* as long as broad, widest posteriorly, disc convex, sides evenly rounded; lateral anterior spine small; clothed with dense recumbent fuscous pile, darkest in centre of disc. *Scutellum* broad, widely rounded behind. *Elytra* slightly wider than prothorax, parallel, apices truncate, densely clothed with long recumbent fulvous pile; an obscure pale oblique fascia extending outwards about apical ¼; a large black cordate nitid glabrous, coarsely punctate area at base of elytra and surrounding scutellum. *Legs* medium, irregularly clothed with fine pubescence. *Under surface* densely clothed with long lax buff pile. Long. 9 mm.; lat. 3·5 mm.

Hab.—Queensland: Endeavour River. Holotype in Australian Museum.

Close to *C. pauxilla* Pasc., but may be readily distinguished by the glabrous black cordate area at base of elytra surrounding scutellum. This area might possibly have been considered to have been caused by abrasion, but is invariably constant throughout a series of five specimens.

Corrhenes nigrothorax sp. nov.

Robust, head and prothorax black, elytra light brown. *Head* broad, finely punctate, clothed with fine erect grey hairs; antennary tubercles transverse, not prominent; eyes small, finely granulate. *Antennae* much shorter than body, with erect hairs throughout; basal joint obconical, coarsely punctate; joint 3 longer than 4; 4 considerably longer than 5; 5–11 very short, progressively decreasing in length, basally ringed with white. *Prothorax* broad, a little longer than wide, finely and closely punctate, with scattered erect hairs; disc with an indistinct, subnitid median longitudinal carina; lateral anterior spine very small. *Scutellum* broad and short, truncate behind. *Elytra* subnitid, coarsely and sparsely punctate, lightly pubescent, with long erect hairs throughout; apices somewhat narrowly rounded. *Legs* stout, brown, with recumbent white pile. *Under surface* brown with sparse grey pile. Long. 5 mm.; lat. 2·5 mm.

Hab.—North-west Australia. Holotype in Australian Museum.

The smallest species of *Corrhenes* known to me. Close to *pauxilla* Pasc., but is very distinct from that species, the marked division of black head and thorax and light brown elytra being very striking and consistent throughout the series.

Genus Sodus Pascoe, 1854.

? Sodus zic-zac sp. nov.

♀. Robust, dark ferruginous, densely clothed with blackish-brown pubescence; elytra with two transverse white zig-zag bands. *Head* broad, widely and shallowly concave between antennary tubercles, densely clothed with close dark-brown pubescence; frons coarsely punctate; median impressed line inconspicuous except on extreme vertex and frons; antennary tubercles strongly transverse, not prominent; eyes moderate, finely granulate, deeply emarginate. *Antennae* stout, much shorter than body (extending little beyond posterior femora), closely pilose with scattered erect hairs; basal joint strongly obconical, apex rounded; joint 3 much longer than 4; 4 much longer than 5; 5–11 progressively decreasing in length; joints 2–11 speckled with white pubescence (densest on 5–7) and apically narrowly ringed with white. *Prothorax* broad, as wide as long, disc strongly swollen, depressed on anterior and posterior borders, closely pilose, with a white irregular transverse patch (broadest laterally and tapering to centre) about middle, not reaching median line; lateral post-apical spine stout, well developed. *Elytra* wider than prothorax, shoulders prominent, sides parallel, rounding slightly to apex; apices obliquely truncate; densely clothed with blackish-brown pile, palest at apex, with short erect hairs; a broad transverse zig-zag band of dense pure white pile at basal ¼, not quite reaching suture or lateral margin; a similar but narrower white band on apical ¼; behind this with scattered minute patches of white pile and a row of white pilose spots along suture. *Legs* robust, pilose with erect hairs; brown

speckled with white. *Under surface* uniformly brown, pilose; abdominal segments speckled with white (densest on apical segment); basal segment fringed with yellowish hairs. Long. 13 mm.; lat. 4·5 mm. (others in series 11 and 14 mm. long.).

Hab.—Queensland: Bowen and Port Denison. Holotype in Australian Museum.

I have somewhat doubtfully placed this insect in *Sodus*. I am not familiar with the species *S. venosus* Pascoe, recorded from Cape York, but the insect before me appears to agree with reasonable closeness to the definition of *Sodus* by Pascoe and the information given by Lacordaire. Its characters are sufficiently distinct to exclude it from *Penthea* or *Corrhenes*. If it cannot be retained in *Sodus* it will, I consider, be necessary to erect a new genus for its reception. From Pascoe's description, the species described above is very distinct from *venosus*.

THE OCCURRENCE OF THE NEW GUINEA TURTLE (*CARETTOCHELYS*) IN THE MIOCENE OF PAPUA.[1]

By Martin F. Glaessner, Ph.D.,

(Plate x, and Figure 1.)

Introduction.—The fossil forming the subject of the present note was discovered in October, 1940, in a quarry on the road leading from the left bank of the Vailala River (Papua, Gulf Division) near the mouth of Kariava Creek to the drilling site of Australasian Petroleum Company's first exploration well in Papua. The fossil was sent to Port Moresby and handed to the writer by Dr. K. Washington Gray, chief geologist to Australasian Petroleum Company. The quarry was situated 800 feet E. 7° S. from the mouth of Kariava Creek. The writer visited the locality in May, 1941. No further vertebrate fossils were found, but mollusca, corals and foraminifera occur in the same beds the age of which is Upper Miocene.

The fossil remains consisted of the external mould, in medium-grained dark tuffaceous sandstone, of a single highly sculptured bone with a fragment of the bone, $1\frac{1}{2} \times 2$ inches in size, still adhering to the matrix. About one-third of the mould was apparently lost in collecting, but it is likely that only this single detached bone was originally embedded in the rock.

Preliminary examination of the fossil made it clear that it was a fragment of the nuchal plate of a turtle, belonging apparently to the Trionychia but suggesting by its outline the presence of marginal plates in the species. Thus the fossil could not belong to the family Trionychidae, but appeared to be related to the more primitive family Carettochelyidae. The only living representative of this family is the New Guinea Turtle, *Carettochelys insculpta* Ramsay.[2]

Description.—A plaster cast of the mould was made (Pl. x, fig. 1). It shows that the bone was irregularly pentagonal in outline, much wider than long, with a widely arched posterior and postero-lateral margin, a lateral angle of about 120°, shorter, slightly concave, antero-lateral margins and an almost straight long anterior margin which is very slightly concave in outline for about one-fourth of its length on either side of the median line. The preserved bone fragment (Pl. x, fig. 2a, b) belongs to the posterior median part of the plate. On its well-preserved sutural margin we recognize the small, rectangular, median excavation into which the anterior margin of the first neural plate must have been fitted. The arched postero-lateral margins of the nuchal plate were joined to the anterior margins of the costal plates. The well-defined lateral angles and antero-lateral margins indicate the presence of well-developed marginal plates.

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[1] Published by permission of the Directors, Australasian Petroleum Company, Proprietary, Limited, Melbourne, Victoria.

[2] Ramsay.—*Proc. Linn. Soc. N.S.W.*, (2), i, 1886, p. 158. Waite.—Rec. Australian Mus., vi, 1905, p. 110. Ogilby.—*Proc. Royal Soc. Queensland*, xix, 1905, p. 1. Longman—*Mem. Queensland Mus.*, ii, 1913, p. 39. de Rooij.—The Reptiles of the Indo-Australian Archipelago. Part i. Lacertilia, Chelonia, Emydosuchia. Leiden, 1915. Walther.—*Nova Guinea*, xiii, 1922, p. 607.

The external surface of the bone is covered with a *Trionyx*-like granulation consisting of isolated small rounded or elliptical mounds separated by narrower or equally wide anastomosing depressions. The general trend of the ornamentation is irregular or transversal about the central part of the plate, changing to radial arrangement near the posterior and postero-lateral margins and, to a lesser extent, near the anterior edge. There are no markings indicating the presence of horny plates on the bone.

On the internal surface of the bone two strong axially elongated projections are symmetrically arranged close to the posterior margin and to the median line. They rise gradually from the central part of the bone forming steeply inclined, elliptical, slightly saddle-shaped, facets directed backward and downward. Reticulate impressions in front of these projections indicate attachment areas of muscles.

Measurements.—Length of nuchal plate (reconstructed), 75 mm.; width of nuchal plate (reconstructed), 130 mm.; width of anterior margin of nuchal plate, 104 mm.; width of antero-lateral margin (nuchal-marginal suture), 40 mm.; suture joining nuchal and first neural plates, 11 mm.; angle between postero-lateral and antero-lateral margins, 120°; computed length of carapace (based on the proportions of *Carettochelys insculpta* Ramsay), 600 mm.

Comparison.—The peculiar surface sculpture of the bone points to the Trionychia as the only group of turtles in which this type of ornamentation combined with the absence of horny plates is a general distinctive feature. The presence of marginal plates is clearly indicated by the outline of the nuchal plate here described. In the Trionychidae proper, in which the marginal plates are absent, the nuchal plate has no distinct antero-lateral margin and the lateral angle is acute or split into a number of projecting spines. A detailed comparison of the newly discovered bone with the nuchal plate of *Carettochelys insculpta* Ramsay reveals almost complete identity.

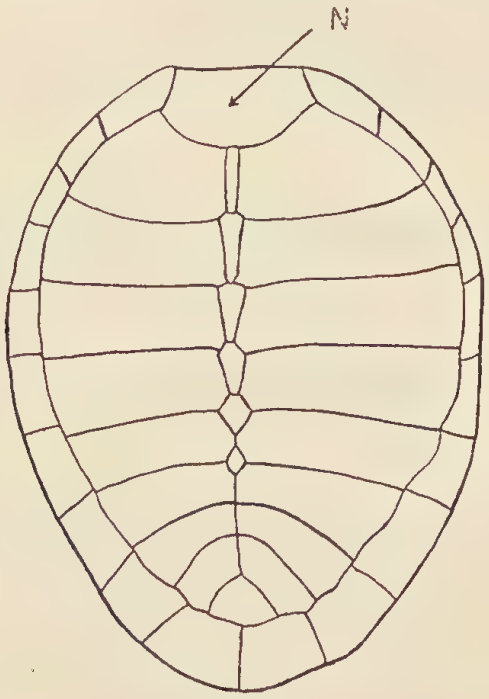

FIGURE I.
Carapace of *Carettochelys insculpta* Ramsay. Dorsal view. One-fourth natural size. After Hummel. N = Nuchal plate.

Walther[3] describes the nuchal plate of this species as follows: The nuchal plate in *Carettochelys* is wide in its central part and narrower in its posterior part. It is firmly connected with the surrounding elements of the carapace. Its anterior margin is arcuate and vaulted in accordance with the shape of the carapace. The well-expressed granulations of its surface resemble more the sculpture of the marginal than of the costal plates, being circular in outline as in the former. On the posterior part of the

[3] Walther.—*Loc. cit.*, p. 616.

internal surface of the nuchal plate there are two strong protuberances serving as condyli for the eighth cervical vertebra. Together with the strongly raised anterior articular processes of the first pectoral vertebra they form a deep socket in which the peculiar roll of the last cervical vertebra is inserted, articulating with the protuberances. These form some kind of locking device preventing the last cervical vertebra from moving beyond a certain point. Such protuberances are not found in *Trionyx*, but are known in *Anosteira*. In front of these projections we see two depressions with rough surfaces representing areas of attachment for the cervical muscles. They contain on each side a foramen for nerves or blood vessels. The deep depressions extending across to the costal plates in *Trionyx* and according to Ogushi serving as a socket for the scapulae are not clearly developed in *Carettochelys*.

Figures published by Walther and Hummel[4] show the angle between costal and marginal sutures on the nuchal plate of *Carettochelys* to be approximately 120° (Fig. 1), The width of the first neural plate equals about one-twelfth of the width of the nuchal plate in the recent species as well as in the fossil specimen.

These comparisons reveal almost complete identity between the observable features of the fossil specimen and the characters of the corresponding plate of the living *Carettochelys insculpta* Ramsay. While this appears to prove at least generic identity, no other known turtle having a nuchal plate of the same shape and dimensions, specific identification can obviously not be based on the examination of a single bone. Until further remains are discovered the fossil form should therefore be known as *Carettochelys* sp.

Relationships and History of Carettochelys insculpta.—Carettochelys insculpta was discovered in 1885 by the Everill Expedition of the Royal Geographical Society of Australasia on the Strickland River in Western Papua, probably 100–150 miles above its junction with the Fly River.[5] Another specimen was caught about 150 miles further south in the Morehead River,[6] and the species is also known from Netherlands New Guinea,[7] from the Lorentz River, Merauke, Setakwa River, and Lake Jamur. As far as recent forms are concerned, these are the only occurrences of the species, genus and family.

Beginning shortly after its discovery and continuing up to recent years, there has been a considerable amount of discussion on the relations of this family to other living and fossil turtles. The question was lately reviewed by Hummel in his comprehensive study of the fossil Trionychia. The family Carettochelyidae includes the Eocene genus *Anosteira* Leidy. According to Hummel, *Pseudotrionyx* Dollo and possibly several other incompletely known Eocene forms belong to *Anosteira*. Morphologically the Carettochelyidae are more primitive than the Trionychidae which are known already from the Upper Cretaceous, and appear to provide a link between them and the typical Cryptodira.

Although we have still no definite knowledge of the antiquity of *Carettochelys* in New Guinea, it is an interesting fact that the genus existed there in Miocene times. Discussing the history of the family Carettochelyidae for which he assumes an Asiatic origin, Hummel[8] states: "*Carettochelys* exists in New Guinea probably as a relic of the Upper Mesozoic, like the Australian marsupials; the known species of *Anosteira* occur in the Eocene. They lived at a time when New Guinea and Asia were already disconnected. That *Carettochelys* did not migrate to New Guinea in Cainozoic time like *Pelochelys* is shown by the fact that *Carettochelys* is restricted to New Guinea while *Pelochelys* is widely distributed on the Asiatic continent."

The latter contention gains further weight by our new discovery, as it is unlikely, in the present writer's opinion, that any part of the island of New Guinea was land connected with or close to either Asia or Australia at any time between the Eocene and

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[4] Hummel.—*Geologische und Palaeontologische Abhandlungen*, (n.s.), xvi, 1929, fig. 11a.
[5] Ramsay.—*Loc. cit.* Waite.—*Loc. cit.*
[6] Longman.—*Loc. cit.*
[7] de Rooij.—*Loc. cit.* Walther.—*Loc. cit.*
[8] Hummel.—*Loc. cit.*, p. 94. The translation is mine.—M.F.G.

the late Pliocene or Pleistocene. The regressive phase at the boundary between Cretaceous and Tertiary is the most likely time of immigration for a non-marine species existing in New Guinea in Miocene time.

Ecology of Carettochelys.—Carettochelys is a typical river-turtle, and does not appear to differ in its habits from the Trionychidae. Walther considers migration along the coast from one river to another as possible, and Hummel,[9] speaking of the Trionychia in general, remarks: "The sea does not form an impassable barrier for the Trionychia. Repeatedly, as for example in the harbour of Wladiwostok and on the coast of West Africa, living *Trionyx* have been observed in the sea. Trionychia can also live in lagoons. . . . It is likely, however, that *Trionyx* makes such excursions into the sea only rarely and probably not altogether voluntarily. . . . It cannot be definitely decided whether the wide range of *Trionyx* throughout the islands of the Western Pacific and Indonesia has any connection with the ability of these animals to swim across the arms of the sea. . . ." The present writer,[10] having examined the occurrence of fossil turtles in the Miocene of Central Europe, came to the conclusion that it has to be assumed that *Trionyx vindobonensis* had its regular habitat in the littoral swamps or brackish lagoons of the Sarmatian sea.

It is perfectly clear that the occurrence of the single detached bone of *Carettochelys* found in the marine Miocene of Papua does not indicate that this turtle lived exactly at the place and in the environment in which its remains have been buried and found. The beds which contain marine foraminifera, corals, and mollusca, consist of interbedded coarse and fine terrigenous material rich in comminuted lignitic plant remains. Current action during deposition is evident in many places. These currents must have brought the bone from the swampy shore or brackish lagoon, possibly connected with a river estuary which was the probable habitat of the fossil *Carettochelys*.

EXPLANATION OF PLATE X.

Carettochelys sp. Upper Miocene, Kariava Creek, Vailala River, Gulf Division, Papua.

1. Nuchal plate, dorsal side. Plaster cast taken from natural mould. Outline restored (dotted line).

2*a*. Nuchal plate. Posterior median fragment. Dorsal view.

2*b*. Same specimen, ventral view.

All figures natural size.

Specimens in the Palaeontological Collection of the Australian Museum, Sydney, Reg. Nos. F 39826-7.

Photographs by G. C. Clutton.

[9] Hummel.—*Loc. cit.*, p. 72. The translation is mine.—M.F.G.

[10] Glaessner.—*Neues Jahrbuch für Mineralogie, Geologie, und Paläontologie.* Beilage, lxix, B, 1933, p. 374.

THE GALLARD COLLECTION OF PARASITIC NEMATODES IN THE AUSTRALIAN MUSEUM.

By T. Harvey Johnston, M.A., D.Sc., and Patricia M. Mawson, M.Sc.,
University of Adelaide.

(Figures 1–18.)

During a period of many years, Mr. Luke Gallard, formerly an inspector belonging to the Department of Agriculture, New South Wales, made a collection of parasites, chiefly nematodes, from the fauna of the Gosford and Kenthurst districts where his official duties lay. This collection was placed in the Australian Museum and was recently forwarded to us for identification. Our thanks are due to the Director, Dr. A. B. Walkom, for the opportunity to study it. We also acknowledge assistance from the Commonwealth Research Grant to the University of Adelaide. All material, including types of the new species, is housed in the Museum, the registered numbers being indicated.

The following is a list of the identifications, arranged under their respective hosts:

Pseudechis porphyriacus Shaw: *Physaloptera confusa* J. & M., Narara and Gosford. *Ophidascaris pyrrhus* n. sp., Narara. *Polydelphis* sp., Narara, Gosford.

Python spilotes Lacep.: *Ophidascaris filaria* (Duj.), Tuggerah. *Polydelphis anoura* (Duj.), Tuggerah. *Polydelphis* sp. (? *anoura*), Gosford.

Varanus varius Shaw: *Physaloptera* sp., Kenthurst.

Amphibolurus barbatus Cuv.: *Strongyluris paronai* (Stoss.), Kenthurst. *Physaloptera gallardi* n. sp., Narara.

Tiliqua scincoides Shaw: *Pharyngodon australis* n. sp., Narara.

Menura novae-hollandiae Lath.: *Porrocaecum menurae* n. sp., Gosford.

Macropus ualabatus Less. & Garn. (= *Wallabia bicolor* Desm.): *Pharyngostrongylus gallardi* n. sp., Ourimbah.

Strongylata.

Pharyngostrongylus gallardi n. sp. (Figs. 1–4.)

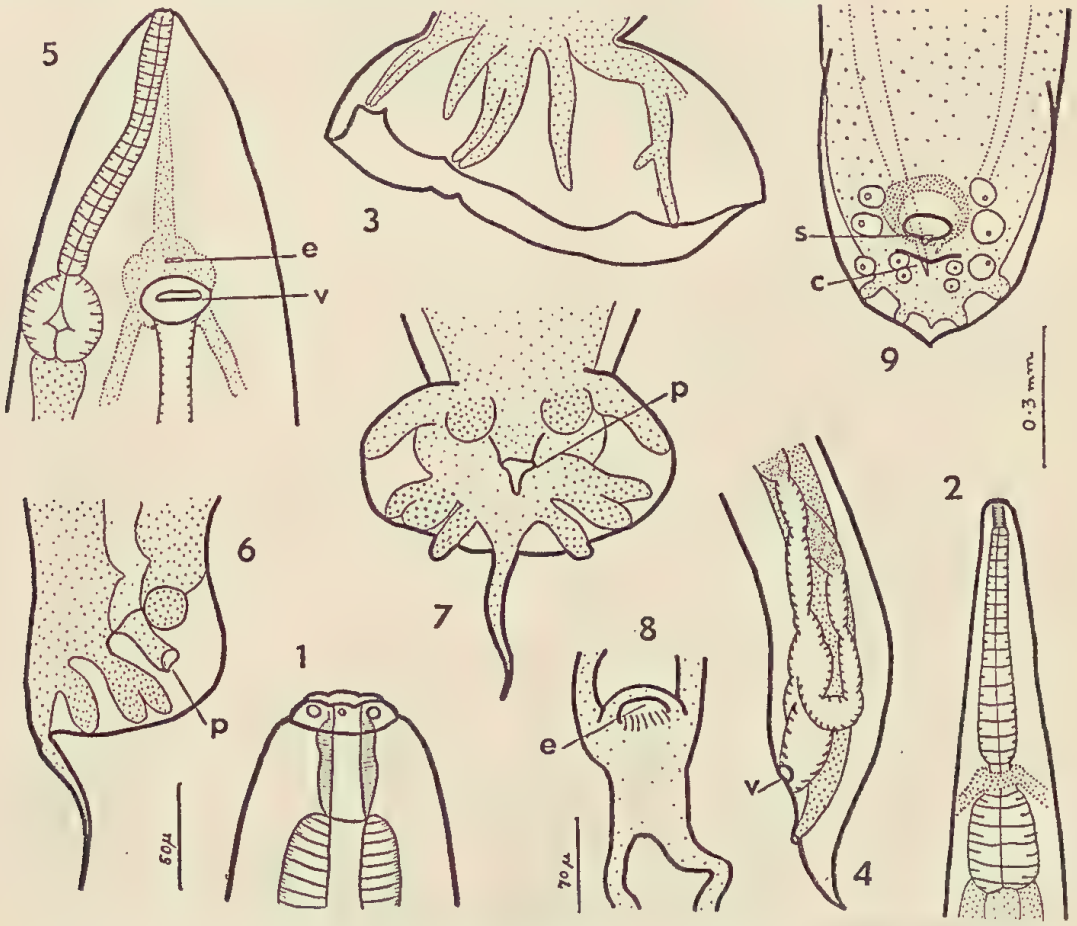
From the oesophagus of a black wallaby, *Macropus ualabatus*, from Ourimbah (W3252). Males and females present. Body filiform, strongly coiled in three to four spirals. Head rounded; six shallow lips, each with low rounded papilla, papillae on lateral lips smaller than those on sub-median. Vestibule 45μ long, 13μ internal diameter, walls transversely striated, thicker anteriorly than posteriorly. Oesophagus (in male) ·75 mm. long, anterior portion ·5 mm. long, widening somewhat towards base, terminated by sudden constriction, and followed by bulb ·2 mm. long, ·15 mm. wide. Nerve ring at level of oesophageal constriction; excretory pore in region of bulb.

Male: About 9 mm. in length. Spicules about ·9 mm. long, with striated alae. Bursa not deeply lobed, inner surface devoid of papillae. Ventral rays equal, almost reaching bursal edge; ventro-laterals short, divergent from other laterals; medio- and postero-laterals of same length, not quite reaching bursal edge; externo-dorsal arising with laterals but divergent from them; dorsal bifurcating at one-third its length, each branch projecting slightly at margin of bursa, and giving off short lateral ray just beyond mid-length.

Female: About 15–18 mm. long. Body tapering posterior to vulva; tail pointed, directed dorsally. Vulva at ·35 mm., and anus ·23 mm., from tip of tail. Vagina ·2 mm. long; ovejectors ·35 mm. long. Eggs about 100μ by 50μ.

The species most closely resembles *P. parma* J. & M. and *P. theta* J. & M. in the characters of the bursa, i.e. the absence of deep clefts between the lobes and of papillae inside the bursa. It differs from both in the shape of the vestibule walls, from *P. theta* in the coiled habit of the body, and from *P. parma* in the shape of the dorsal ray and of the female tail.

It is perhaps noteworthy that the two species of *Pharyngostrongylus* (*P. parma* and *P. gallardi*) which have been recorded from the gullet of the host animal have each a long thin body coiled in a spiral, whereas other members of the genus, usually taken from the stomach, sometimes from the intestine, are relatively stouter and have a more or less straight body. This new species would be ranged along with *P. theta* in our key to species of the genus (J. & M. 1940, 365), and is most readily separated from it by the shape of the vestibule and by the lengths of the spicules.



Figs. 1-9.—1-4. *Pharyngostrongylus gallardi*; 1. head; 2. anterior end; 3. bursa; 4. posterior end of female. 5-8. *Pharyngodon australis*; 5. anterior end of female; 6. lateral, and 7. ventral, views of male tail; 8. excretory vesicle of male. Fig. 9. *Strongyluris paronai*, male tail. Figs. 1, 6 and 7 to same scale; Figs. 2, 4, 5 and 9; Figs. 3 and 8. c, cloaca; e, excretory pore; p, prolongation of cloacal wall; s, sucker; v, vulva.

Oxyurata.

Pharyngodon australis n. sp. (Figs. 5–8.)

From *Tiliqua scincoides*, Narara (W3279). Males 3–3·2 mm. long; females 8 mm. Three lips, each slightly bilobed. Oesophagus ·5 mm. long in male; ·75–·77 mm. in female; narrow, with spherical bulb. Nerve ring ·23 mm. from head in female. Excretory pore in female in oesophageal region, ·5 mm. from head; but far behind it in male, ·8 mm. from head.

Male: Excretory vesicle apparently formed from two vessels from posterior and two from anterior end of body. Lateral alae extending to anterior end of the wide caudal alae. Latter supported by two pairs postanal papillae, the anterior pair bifid,

the posterior projecting beyond alae; also a air of sessile preanal papillae. Spicule absent, but wall of cloaca thickened and projecting as a strong posterior lip. Anus ·13 mm. from posterior end. Projecting spike of tail 80–90μ long.

Female: Tail narrow, pointed, devoid of spines, exact position of anus not seen. Vulva ·55 mm. from head, just behind excretory pore. Excretory vesicle appearing to be formed by union of two vessels from posterior and one from anterior end of body. This discrepancy between male and female excretory systems suggests that the worms belong to different species, but as they were found side by side in the host, and no other parasites were present, this seems unlikely. Probably the nearness of the pore to the anterior end in the female accounts for the presence of only one vessel anterior to the pore. Eggs 125μ by 30μ.

The species differs from *P. hindlei* Thapar in the number of bursal papillae in the male, and in the position of the excretory pore in the female and in the size of the eggs. Thapar mentioned the presence of a spicule, but Baylis has recorded the species from the type host *Tiliqua scincoides*, in Queensland, in which spicules were absent. The present species differs from *P. tiliquae* Baylis in the size of the body, in the position of the vulva, and the size of the eggs, as well as in the length of the spike of the male tail relative to the width of the caudal alae.

Ascaridata.

Strongyluris paronai (Stossich). (Fig. 9.)

From a "frilled lizard", presumably *Amphibolurus barbatus*, from Kenthurst (W3253). Males 14–16 mm. long, ·9 mm. wide; females 20–23 mm. long, 1 mm. wide. Lateral alae absent. Oesophagus thin, ending in bulb; anterior part ·2 mm. long in male, ·32 mm. in female; total length 1·94–2·3 mm. in male, 2·4–2·5 mm. in female. Nerve ring ·56 mm. and excretory pore 2·2 mm. from head end in male 16 mm. long.

Male: Tail ·15 mm. long with very small terminal spike. Caudal alae narrow, forming an almost circular bursa-like expansion. Sucker ·05 mm. in front of cloaca, its aperture rather posteriorly directed, apparently a small papilla on its posterior border. Seven pairs papillae present (fig 9). Spicules more or less equal, about ·9 mm. long, ending in fine rounded tips.

Female: Tail ·24 mm. long with minute terminal spine. Vulva 7·7 mm. (one-third body length) from posterior end of body. Eggs thick-shelled, 70μ by 48μ.

The species was described by Stossich (1902) as *Strongylus paronai* from *Amphibolurus muricatus* from Australia, and it was under that name that Johnston (1911) recorded it from *A. barbatus* from Moree, N.S.W., and from *Chlamydosaurus kingii* from Eidsvold, Queensland. Our material differs from Stossich's account in the number of papillae on the male tail. What he described as the cloaca is apparently, from his figure, the sucker, the papillae seen by him on posterior border of the cloaca being comparable with those found on the sucker in other species.

Ophidascaris filaria Dujardin.

From *Python spilotes*, from Tuggerah (W3251). Male 105 mm. and females to 165 mm. long. No marked enlargement of posterior third as described below for *O. pyrrhus*. Pulp of dorsal lip projecting as stated by Baylis.

The parasite had been reported from the same species of *Python* by Canavan (1931) whose material was taken from a snake which had been three months in the Philadelphia Zoological Gardens, but had originally come from Tasmania. Baylis (1921) had previously reported it from *Python* sp. from Australasia.

Ophidascaris pyrrhus n. sp. (Figs. 10–11.)

From a black snake, *Pseudechis porphyriacus*, from Narara (W3300). Males 70–80 mm. long, ·8 mm. wide; females to 130 mm. long, 2·2 mm. wide. Body much wider in posterior third in both sexes. Interlabia short, about a third length of lips, grooves extending almost to middle of lips; no prolongations of pulp of dorsal lip observed. Oesophagus 3·5–5 mm. long; nerve ring ·72 mm. from head in male.

Male: Spicules equal, 4·1–4·8 mm. long, blunt tipped, alate. At least 20 pairs preanal papillae, one median preanal papilla, six airs postanal, most anterior of latter double-headed and just behind cloaca, remainder in two groups on each side (fig. 11). Tail ·15 mm. long, ending in small knob.

Female: Tail rounded, ending in small knob. Vulva about third body length from tail end, just posterior to beginning of swollen part of body. Eggs 58–62μ by 75–81μ.

We consider the present species distinct from *O. filaria* because of its width in relation to its length, the shape of the pulp of the dorsal lip, the relative length of spicules, and the size and shape of the eggs.

McAlpine (1891) described *Ascaris* sp. from the copper-head snake, *Denisonia superba*, from Victoria, and his brief account, based on a female, suggests an *Ophidascaris*, probably *O. pyrrhus*.

Polydelphis anoura Duj. (Figs. 12–14.)

From *Python spilotes*, Tuggerah (W3299). Males 46 mm. long; female 62 mm. long, 1 mm. wide. Lips slightly wider posteriorly than anteriorly. Dentigerous ridges very fine. Oesophagus 5·68 mm. long in male, ·6 mm. in female.

Male: Caudal alae absent. Five pairs postanal papillae, one median preanal papilla, one pair large adanal, and nine or more pairs preanal. Spicules equal, 5·1 mm. long, thin, blunt-tipped, alate. Tail ·3 mm. long.

Female: Tail conical, pointed, ·4 mm. long. Specimen immature, but on dissection four ovarian tubes seen about middle 10 mm. of body, each widening into small receptaculum seminis before joining its uterus; four uteri running side by side towards anterior end, uniting about 5 mm. behind vulva to form single uterus, latter narrowing to vagina; vulva at about one-third body length from head. No eggs present.

The measurements given for these specimens are similar to those of *P. oculata* Linst. Linstow, however, mentioned only two pairs of postanal papillae. Baylis (1936) pointed out that, apart from its smaller measurements, *P. oculata* bore a close resemblance to *P. anoura*. The present specimens have relatively shorter spicules than *P. anoura*, but since they are young worms, it is suggested that this discrepancy would be less in the adult; we have recorded them as *P. anoura*.

Polydelphis spp.

(1) Female from *Python spilotes*, Gosford (W3260). 70 mm. long, 1·5 mm. wide. No interlabia. Body strongly coiled so that distinctive features not available. The general appearance suggests an adult female of *P. anoura*.

(2) Specimen of undetermined sex from *Pseudechis porphyriacus*, Narara (W3250). Length 160 mm., width 3 mm. No interlabia. Posterior end very thick, resistant to clearing even when using creosote, but structures are present which may be papillae.

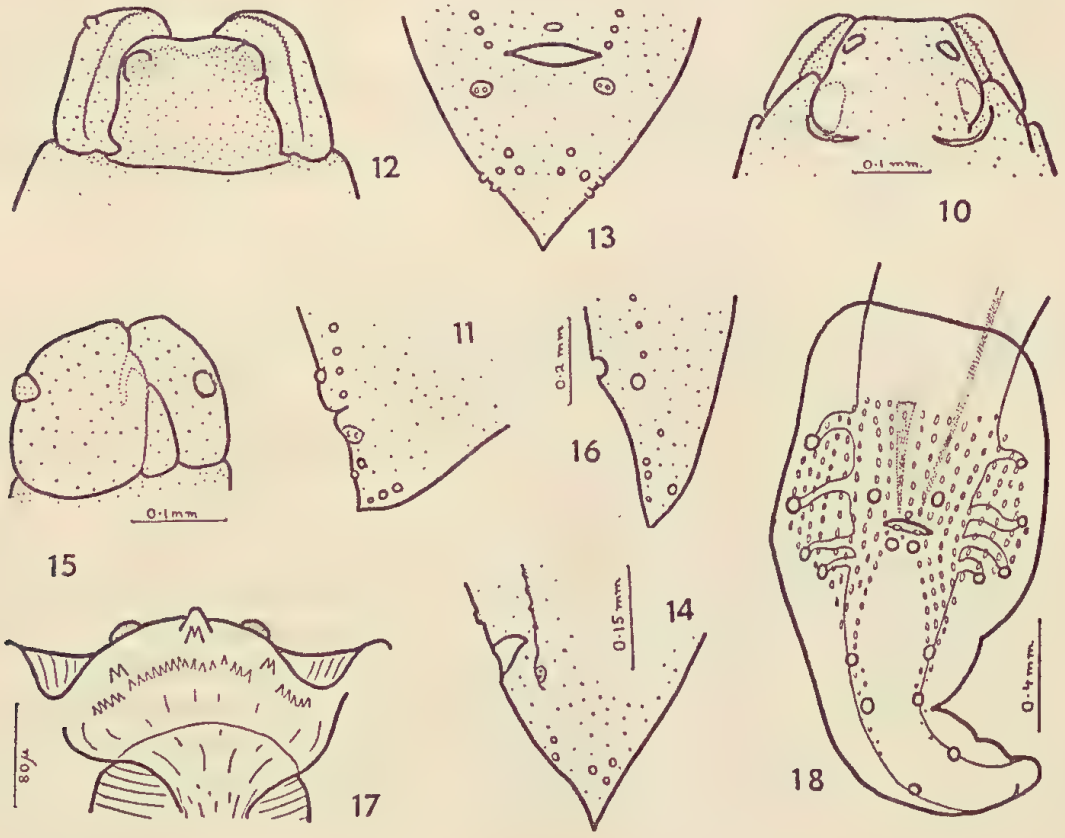
(3) Mutilated female from *Pseudechis porphyriacus*, Gosford (W3298). 86 mm. long, 1 mm. wide.

Porrocaecum menurae n. sp. (Figs. 15–16.)

From a lyre bird, *Menura novae-hollandiae* (W3287). One male only present, not well cleared. Length 35 mm., width 1 mm. Head as wide as body following. Interlabia nearly as long as lips. Lips provided with lateral flanges, dentigerous ridges present. Oesophagus 2·8 mm. long (excluding ventriculus, ·36 mm. in length), ·16 mm. wide. Intestinal caecum not observed. Tail ·4 mm. long, ending in point. About twelve preanal paillae on each side, the most posterior being almost level with cloaca. Six pairs postanal papillae, one large pair near cloaca, the remaining five on posterior half of tail (fig. 16). Spicules not clearly seen; one (probably the longer) about ·7 mm., the other possibly ·5 mm.

The species differs from *P. clelandi* J. & M. from Australian thrushes in the width of the head in relation to that of the body, and in the number of postanal papillae. It differs from *P. streperae* J. & M. from Australian *Strepera* spp. in the presence of a

dentigerous ridge on the lips. It most resembles *P. ensicaudatum* Zed. from European *Corvus*, but in view of the lack of information regarding the length of the intestinal caecum and the spicules in our specimens and because of the host relationships we have preferred to assign it to a new species.



Figs. 10-18.—10-11. *Ophidascaris pyrrhus*; 10. head of young female; 11. male tail. 12-14. *Polydelphis anoura*; 12. head; 13. ventral, and 14. lateral, views of male tail. 15-16. *Porrocaecum menurae*; 15. head; 16. male tail. 17-18. *Physaloptera gallardi*; 17. inside of a lip; 18. male tail. Figs. 12 and 17 to same scale; Figs. 11, 13 and 14.

Spirurata.

Physaloptera gallardi n. sp. (Figs. 17–18.)

From intestine of *Amphibolurus barbatus*, Narara (W3257). Males 14–16 mm. long; females to 20 mm. Lips each bearing one median pointed tooth anteriorly, and on inner border three bifid teeth, in dorsal, median, and ventral positions, as well as a row of large denticles, arranged as in fig. 17, these denticles so large as to be seen quite distinctly from outer surface in undissected specimens. Muscular part of oesophagus longer than usual in genus, ·56 mm. in length in female; ·44 mm. in male; glandular part 2·72 mm. in male. Nerve ring ·36 mm., and excretory pore ·63 mm. from head end in male. Cervical papillae symmetrically placed, very small, ·84 mm. from head in female.

Male: Bursa 2 mm. long, cloaca 1·3 mm. from tip of tail. Alae not quite reaching tip of tail; papillae arranged as in fig. 18. Spicules very unequal; shorter, ·5 mm. long, tapering to a point; longer, 2·8 mm., very fine, its tip almost certainly without enlargement.

Female: Tail 1·2 mm. long. Position of vulva not determined owing to density of worm. Eggs 55μ by 30μ, flattened on one side.

The species resembles very closely *P. bancrofti* Irwin-Smith, but differs from it in size of denticles on the lips as well as in the size of the worms. The arrangement of caudal papillae resembles that of *P. varani* and *P. paradoxa*, but the species differ in dentition and in the spicule length.

Physaloptera confusa J. & M., 1942.

From *Pseudechis porphyriacus*, from Narara (W3247, W3248) and Gosford (W3286). These specimens agree in all respects with the types of the species. Denticles on the inside of the lips were observed in very few cases.

Physaloptera sp.

Specimens from *Varanus varius* from Kenthurst (W3249). The material consists of three females, about 15 mm. long. In general form they agree with *P. antarctica* Linst., but the median inner tooth is not bifid. In view of the paucity of the material we prefer not to assign the parasites to any species.

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A NEW SPECIES OF SILVER-FISH FROM LORD HOWE ISLAND.

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South Australian Museum.

Heterolepisma howensis sp. n. Figures 1-15.

Description.—Length, both sexes, 8·0 mm., width across thorax 2·0 mm., length of median tail appendage 7·0 mm., of cerci 4·0 mm., of antennae 4–5·0 mm.

Colour (in spirit), greyish to brownish, antennae, cerci and tail appendage annulated with brown and white.

Thorax with almost parallel sides, abdomen slightly tapering.

Head with a single lateral comb of 3 macrosetae, besides the usual marginal series which include 6–7 macrosetae on each side. Antennae with approximately 20 segments. Maxillary and labial palpi and mandibles normal as figured.

Thorax: All tergites with a single submedian posterior macroseta on each side; sternite I (fig. 4) with almost straight, converging sides and moderately wide, slightly concave apex, with a series of 4 macrosetae and a few fine setae not extending beyond the posterior fourth of the lateral margins; sternite II (fig. 5) with sides slightly rounded, and apex broader and slightly concave, setae as in I but confined to posterior sixth of lateral margins; sternite III (fig. 6) wider than long, with curved sides and slightly concave apex, with the macrosetae forming a brush at the posterior corners, but otherwise devoid of setae as in I and II.

Abdomen: Tergites (fig. 9) with combs of macrosetae on posterior margins as follows: I, 2.1.0 + 0.1.2; II–VI, 3.2.1 + 1.2.3; VII, 3.3.1 + 1.3.3; VIII, 3.1 + 1.3; IX, 2.0 + 0.2. Sternites II–VI (fig. 10) with a single submedian posterior macroseta on each side. Tergite X wider than long, with broadly truncate apex and macrosetae as figured.

Stylets present on sternites VII–IX in female, on VIII–IX in male; on VII and VIII slightly less than half as long as those on IX. Ovipositor reaching to about half the length of cerci.

Remarks.—Closely related to *H. stilivarians* Silv. from Western Australia and South Australia, but differing as follows:

(1) All thoracic sternites without the finer setae extending along the lateral margins (compare figures 11–13 of *stilivarians*).

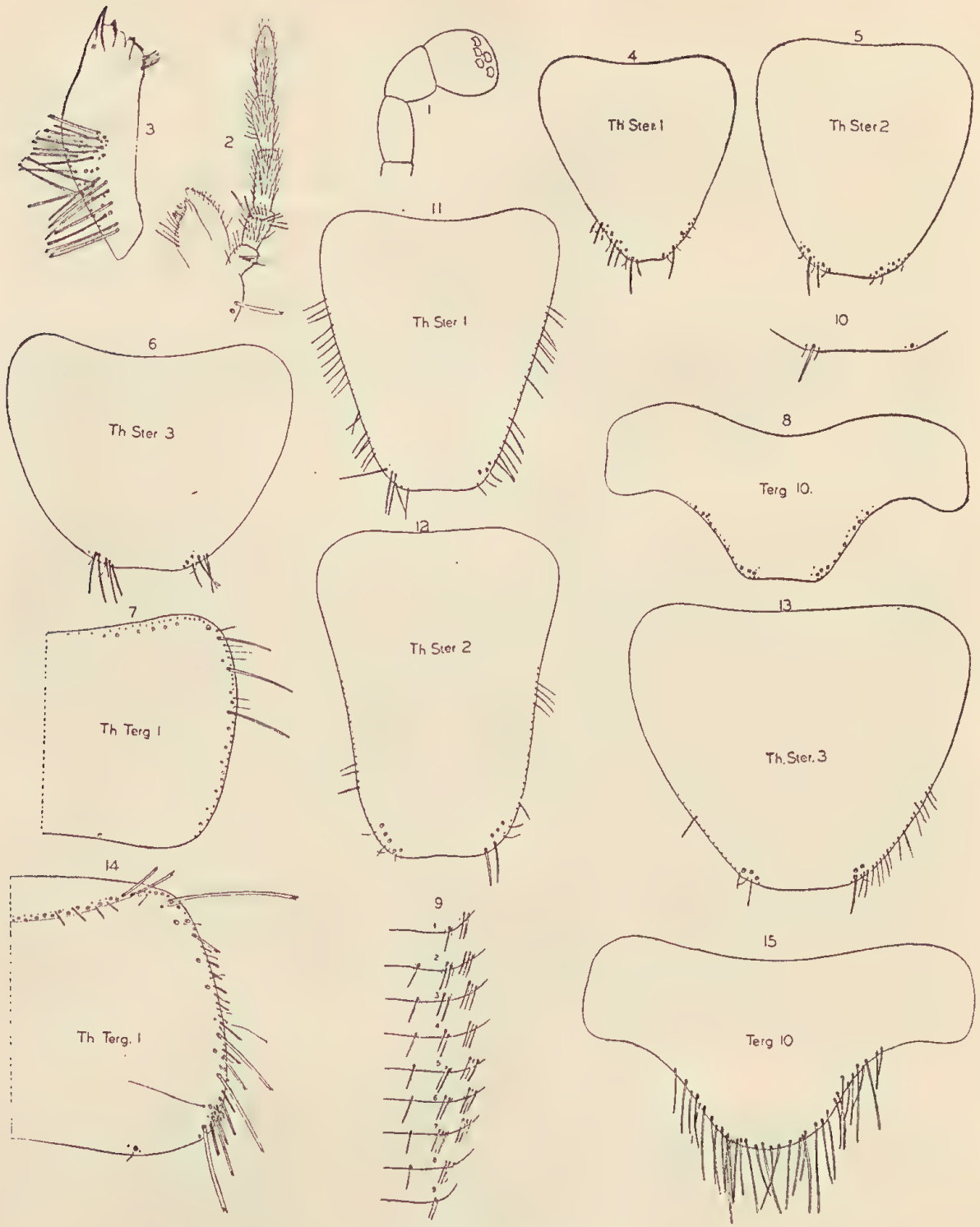
(2) Apex of tergite X truncate and not rounded.

(3) *H. stilivarians* has 5 stylets in the female and 4 in the male; although Silvestri recorded specimens of the female sex with 4 and 3 stylets only, these on further study might prove not to have been the same species. *H. howensis* has 3 stylets in the female and 2 in the male.

Locality.—Numerous specimens from Lord Howe Island, 1942, collected by Mr. Max Nicholls and referred to me for study by Dr. A. B. Walkom, Director, Australian Museum, Sydney.

Type male (reg. no. K 67623), allotype female (reg. no. K 67624), and twenty-six paratypes are in the Australian Museum; other paratypes in the South Australian Museum, Adelaide.

Mr. Nicholls states: "It is found under the bark of trees known as Kilinogue. Specimens are from Rocky Run, a creek between Rocky Point and Boat Harbour, east coast of island."



FIGURES 1-15.

Heterolepisma howensis sp. n.

Fig. 1, Labial palp. 2, Maxillary palp. 3, Mandible. 4, Thoracic sternite I. 5, Thoracic sternite II. 6, Thoracic sternite III. 7, Thoracic tergite I, right half. 8, Tergite X. 9, Abdominal tergites I to IX, right halves of posterior margins. 10, Abdominal sternite III, posterior margin.

Heterolepisma stilivarians Silv.

Fig. 11, Thoracic sternite I. 12, Thoracic sternite II. 13, Thoracic sternite III. 14. Thoracic tergite I, right half. 15, Tergite X.

HERPETOLOGICAL NOTES NO. 4.

By J. R. Kinghorn.

(Figure 1.)

This paper contains the description of a new species of *Typhlops*; notes on *Denisonia daemelii*, *Acanthophis pyrrhus*, *Hydrophis ornatus ocellatus*, and remarks on the status and affinities of *Demansia psammophis*, *Denisonia fasciata*, *Oedura rhombifer* and *Oedura marmorata*.

Typhlops yirrikalae, sp. nov.

(Figure 1.)

Definition.—Nasal cleft in contact with the first labial. Scales in 24 rows round the centre of the body. Head and snout rounded. Nostrils inferior, nasal not completely divided, the nasal cleft terminating a fraction in front of the nostril, and not visible from above. Rostral from above, rounded, as broad as long, more than half the width of the head, and not extending back to the level of the eyes; the portion visible from below is broader than long. Preoculars narrower than the nasals, the latter forming a narrow suture, separating the prefrontal from the rostral. Frontal smaller than the prefrontal. Parietals and inter-parietals about equal in size, but not much larger than the nuchals. Total length 182 mm. Width about 3 mm.

Colour, in spirits.—Uniform yellowish, with no indication of spots or striations.

Locality.—Yirrikala Mission Station, near Caledon Bay, Arnhem Land, Northern Territory.

Affinity.—The general shape of the head of *T. yirrikalae* is like that of its nearest relative *T. nigrescens*, but it differs in having 24 rows of scales, the nasal groove terminating just beyond the nostril, and a broader rostral.

Holotype.—In the Australian Museum, Reg. No. R.12381. Described from a single specimen, collected by the Rev. W. Chaseling.

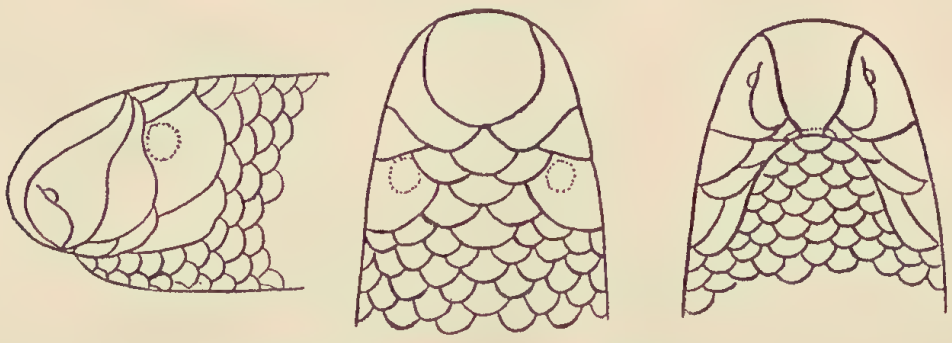


Figure 1.—*Typhlops yirrikalae*, sp. nov.

Demansia psammophis Schlegel.

Elaps psammophis, Schlegel, Phys. Serpens., ii, 1837, p. 455.
Diemenia psammophis, Blgr., Brit. Mus., Cat. Snakes, iii, 1896, p. 322.
Demansia torquata, Gnth., Ann. Mag. Nat. Hist., (3), ix, 1862, p. 130.
Diemenia olivacea, Blgr., Brit. Mus., Cat. Snakes, iii, 1896, p. 323.
Elapognathus ornaticeps, Macl., Proc. Linn. Soc. N.S.W., ii, 1878, p. 221.
Diemenia ? ornaticeps, Blgr., Brit. Mus., Cat. Snakes, iii, 1896, p. 324.

There has been a great deal of confusion regarding this and allied species; and like Loveridge I have always found great difficulty in identifying some specimens from Boulenger's key and descriptions. When Loveridge reduced *T. olivacea* to subspecific rank, and suggested that perhaps *psammophis*, *olivacea* and *torquata* were related even more closely to each other than the term subspecies indicated, his action caused me to examine all the specimens in the Australian Museum collection, together with Macleay's type of *Demansia ornaticeps* and a second and larger Macleay specimen from Darwin. At present I am unable to examine material from all Australian collections, but have sufficient before me to go further than Loveridge, and place *olivacea*, *torquata* and *ornaticeps* in the synonymy of *psammophis*.

Loveridge suggested that *torquata* may not be anything other than a colour mutant of *psammophis*, but I think that I am right in regarding it, as well as *ornaticeps* and the smaller, more highly marked, specimens of *olivacea*, as juvenile stages only. It is true that there is a tremendous difference between the young *torquata*, with its black head and two outstanding white bars on nape, and the adult *olivacea*, with no distinctive markings other than a few dark spots on the head shields. It might be advisable to support these contentions by directing attention to the various stages of *Demansia textilis*; the adult being uniform brown of various shades, whilst the young, even those from the same batch of eggs, may be variously marked, some being uniformly brown, others bear dark cross bars, and most have a black head crossed with white occipital bars somewhat similar to *torquata*.

Until recently, when specimens typical of *torquata* were found at two points in western Queensland (Cooper's Creek and Mount Morgan), this form may have been regarded geographically as from the coastal areas only, but a specimen from Port Darwin, collected in 1923, has very definite, though faded, *torquata* markings, and is a link between *torquata* and the younger *olivacea*.

A very small specimen from Groote Eylandt, Gulf of Carpentaria, the same size as Macleay's *ornaticeps*, is identical in scalation with the latter. In colour it resembles *ornaticeps*, except that there are no markings on the upper head shields, and the markings on labials, chin and throat are frecklings rather than blotches.

An important fact which must be recorded here is that my figure of *ornaticeps*[1] was from a wrongly identified specimen, now known to be *Aspidomorphus muelleri muelleri*, which superficially resembles *D. ornaticeps*. I have examined Macleay's type of the latter and find the canthus somewhat rounded (often a characteristic of very young specimens), but the head is deep at the sides, the eye is very large, more than twice as deep as its distance from the mouth, and equal to its distance from the rostral. The markings on the head are patterned in whorls and crescents, not spots as in *Aspidomorphus*, though they are ringed with a lighter colour. The head shields are elongated, and typical of the genus *Demansia*. A noteworthy feature is that the anal shield is divided, not entire as described by Macleay.

Specimens marked as *torquata* are from the following Queensland localities: Percy Island, 250 mm. long; Hughenden, 350 mm.; two from Hayman Island, Whitsunday Passage, 290 mm.; Mount Morgan, 380 mm.; and Nappapari, Cooper's Creek, 650 mm.; the markings of latter being more like those of *olivacea* than *torquata*.

A specimen from Darwin, Northern Territory, so badly damaged about the head that it was about to be discarded, has proved a useful link. It is 600 mm. long, but retains many of the head markings of younger specimens of the *torquata* type.

Macleay's Darwin specimen measures 550 mm., and retains only an indication of the head coloration typical of *torquata*.

Denisonia fasciata Rosen.

Denisonia fasciata, Rosen, Ann. Mag. Nat. Hist., (7), xv, 1905, p. 179. Loveridge, Bull. Mus. Comp. Zool., Harvard, lxxvii, p, 1934, p. 287.

Denisonia maculata, var. *fasciata*, Kinghorn, Snakes of Australia, sm. 8vo, Sydney, 1929, p. 173.

[1] Kinghorn.—Snakes of Australia, 1929, p. 142, fig. 83.

I have examined a specimen from Malcolm, Western Australia, and agree with Loveridge that it is deserving of full specific rank. Superficially the markings resemble those of *D. maculata devisii*, but closer inspection shows the head to be paler, with a few dark spots. There is an irregular dark stripe from the rostal through the eye to the temporal region. The labials are white—not vertically striped as in *devisii*—and the dark zig-zag cross markings on the dorsal surface are more irregularly disposed. The nasal shield is entire and narrowly in contact with the preocular on the right side, but not in contact on the left. The frontal is much longer than broad, and is longer than in *devisii*. The remaining head shields also are elongated, making the head longer in relation to its breadth in comparison to *devisii*. There are 163 ventrals and 29 subcaudals.

Denisonia daemelii Gunther.

Hoplocephalus daemelii, Gunth., Journ. Mus. Godeffroy, xii, 1876, p. 46.

Previously regarded as a Queensland species, this snake has been found at Mount Harris, 30 miles north-west of Nyngan, in central New South Wales. It is a particularly robust specimen, measuring 445 mm. in length, of which the tail is 93 mm. The scales are in 17 rows; anal divided; ventrals 165; subcaudals 45. Boulenger gives the scalation as ventrals 160; subcaudals 39; 147 + 33, and 153 + 45.

Acanthophis pyrrhus Boulenger.

Two specimens recently were received from Hermannsburg, Central Australia. Specimen (A): total length 550 mm.; scales in 21 rows at centre of body; ventrals 145; subcaudals 47 (36 single, 11 paired). Specimen (B): total length 640 mm.; 21 rows of scales; ventrals 150; subcaudals 54 (29 single, 25 paired). The stomach of (B) contained four lizards (*Lygosoma lesueurii*).

Hydrophis ornatus ocellatus Gray.

Hydrophis ocellata Gray, Brit. Mus. Cat. Snakes, 1849, p. 53.

Hydrophis ornatus ocellatus, Malcolm Smith. Mon. Sea Snakes, 1926, p. 84. H. H. Scott, Proc. Roy. Soc. Tasm., 1931 (1932), p. 111. Kinghorn, Snakes of Australia, sm. 8vo, Sydney, 1929, p. 112, fig.

Some years ago Scott recorded this species from Scamander, east coast of Tasmania. The scalation and general characters show an interesting variation from the typical, and are recorded as follows: Scales, round the neck 39; at centre of body 58; ventrals 110; subcaudals 46. There are six upper labials, 1 preocular, 2 postoculars on the left side and 4 on the right. The total length 1310 mm., of which the tail measures 150 mm. The general colour is slate grey above and yellowish white below. The narrow dorsal bands are yellow, and the small spots above the larger ocellate markings are pale blue. Numbers of irregularly disposed dark markings are scattered along the abdominal region.

Oedura rhombifer Gray.

Oedura rhombifer Gray, Zool. "Erebus" and "Terror", 1884, Reptiles, pl. xvi, fig. 6.

Three Western Australian specimens in the Old Collection, previously identified as *lesueurii* (?), are referable to this species. One is from Perth, and two from Boulder, all collected in 1900.

Whilst they agree in markings with the published figure, the tail is not perfectly cylindrical, but is somewhat flattened like that of *lesueurii*. The abdominal scales are mostly hexagonal, the remainder being more evenly rounded.

It is difficult to decide whether they are closer to *rhombifer* or *lesueurii* but form an undoubted link between the two species, and only through lack of further material do I hesitate to relegate *rhombifer* to the synonymy of *lesueurii*.

Oedura marmorata Gray.

Oedura mamorata Gray, Zool. Miscell., 1842, p. 52. Loveridge, Bull. Mus. Comp. Zool. Harvard, lxxvii, 6, 1934, p. 309.

Several specimens from Yirrikala Mission Station, Northern Territory, exhibited such extremely variable markings, in addition to variations or abnormalities in the rostral, mental and chin shields, that I have made an examination of the complete series in the Australian Museum, and unhesitatingly support Loveridge, who placed the several previously accepted species in the synonymy of *O. marmorata.* On extreme colour markings, previously regarded as typical, these species might easily have been regarded as distinct, and it is as such that I have grouped them, but found with these were intermediate kinds which linked all together.

With the exception of *marmorata* Gray and *meyeri* Garman, which have been taken on the coastal areas, the remaining forms are found mainly on the plains, western slopes or tablelands. It appears that the very young specimens are more often distinctly banded—black and greyish-white—and I assume that these bands disappear with age, giving way to spots and ocellate markings. With the exception of the young banded forms, *O. monolis*, figured by Fry,[2] bears the most outstanding markings.

Among those labelled *cincta, tryoni* and *marmorata*, there are many intermediate forms, and though these may be from one or widely separated localities, it is impossible to group them as geographical races.

Loveridge suggests that the lateral stripes of *fracticolor* may have been formed by the coalescence of the more usual markings. I suggest that *fracticolor* may have been described from immature specimens before the markings had broken up.

Loveridge made a thorough examination of the scalation of the various forms, and found that variations in the rostral, mental, infralabials, etc., were abnormalities, and individual rather than specific. An examination of the series before me supports this, and I have little hesitation in agreeing with him in placing *tryoni, fracticolor, ocellata, cincta, monolis, castelnaui*, and *meyeri* in the synonymy of *marmorata.*

On colour markings the series in the Australian Museum were previously grouped, with their localities, as follows:

Oedura tryoni.

Queensland: Cunnamulla, one; Eidsvold, five; Frazer Island, one; north, one; unlocalized, two.

New South Wales: Narromine, one; Moree, two; Tumut, one; Inverell, one (incorrectly recorded from Tamworth by Fry).

Oedura monolis.

New South Wales: Trangie, one (figured by Fry); Mungindi, one (collected by the late D. A. Porter of Tamworth; subsequently recorded by Fry as from there and so referred to by Loveridge, but it had an attached label localizing it from Mungindi); unlocalized, two.

Oedura cincta.

Queensland: Charleville, two. Exchanged with the Queensland Museum—most probably examined by De Vis. Cannot be separated from *ocellata.*

Oedura ocellata.

New South Wales: Ivanhoe, one; Carinda via Coonamble, one. The former is heavily spotted between the cross bands; the later has very few spots.

Oedura marmorata.

Northern Territory: Port Essington, two; Yirrikala Mission Station, six.

Queensland: Cape York, one; Almaden, four; Bowen River, two.

New South Wales: Moree, one.

Unlocalized: three.

The young black and white banded forms are from Yirrikala Mission Station, Northern Territory; western Queensland; New South Wales; and locality (?).

[2] Fry.—Herpet. Notes, Proc. Roy. Soc. Qld., 1915, xxvii, 4, pp. 86-87, pl. iii, fig. 2.

NOTES ON AUSTRALIAN BUTTERFLIES IN THE AUSTRALIAN MUSEUM. No. 2.*

By G. A. Waterhouse, D.Sc., B.E., F.R.E.S.,
Honorary Entomologist, The Australian Museum.

(Figure 1.)

Candalides Hübner, 1819.

This genus was first mentioned in the Verzeichniss, 1819, when Hübner used it for two very dissimilar species. Of these, Scudder (1875) selected as the genotype *C. xanthospilos* Hübn.

The absimilis group of Candalides.

The first mention of any species of this group was by Felder 1862, when he described *Holochila absimilis* from Ash Island, Hunter River, N. S. Wales, received from A. W. Scott. Felder (1865) gave good figures of both sexes.[1] I saw the holotype male at Tring Museum and there is no doubt that it is the species with a uniform blue upperside without any appearance of sex scales on the forewing when viewed either directly or obliquely. I have for long been of the opinion that I have had in the collection at least two species under the name *absimilis*. When Dr. C. P. Ledward found at Burleigh Heads, South Queensland, two distinct types of larvae, I was forced to make an investigation which gave rather surprising results, shown below.

The females of all the species will be very difficult to separate, but, as far as I am able, I give characters from specimens in the Museum collection which will help to distinguish them. I also include the two somewhat similar species described by Semper,[2] where he used the genus *Holochila*. I have seen the types of all the species and their synonyms.

Candalides helenita Semper, 1878. (Figure 1a.)

Male. Upperside greenish-blue, with a trident sex mark on veins 2, 3 and 4 of forewing.

Female. Upperside black, with a large central white patch on both wings, that of hindwing reaching apex, without any blue scales. Underside almost wholly silky-white with very few dark markings, the terminal black spots on hindwing very small. Readily recognized.

Semper's holotype male bears an old label, "Cap York", which is therefore the type locality. It is also found as far south as Cairns and Kuranda, where it has been recorded throughout the year. The female described by Semper, and afterwards figured by Druce, 1902, and seen by me, is a small female of *margarita*. Synonyms are *androdus* Miskin, 1890, Cape York, and *subargentea* G. Smith and Kirby, 1896, Cape York.

Candalides margarita Semper, 1878. (Figure 1b.)

The male has the trident sex mark on the forewing upperside, but the general colour is blue tinged with purple. The female upperside is similar to *helenita*, but has basal blue scales on both wings. The underside of both sexes is more heavily marked than in *helenita*, especially the terminal spots of hindwing.

The holotype male bears an old label, Bowen, which must be taken as the type locality. Semper described and Druce figured (1902) the female as *helenita*.

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* For No. 1, see Records of The Australian Museum, vol. xx, no. 3, p. 217, 1938.

[1] Felder.—Reise der . . . Novara . . . 1857-1859, Zool. ii, 2, 1865, p. 261, tab. xxxii, figs. 14-16.

[2] Semper.—*Journal des Museum Godeffroy*, v, 14, 1879, pp. 161-162. (Separate issued in 1878.)

No doubt often mistaken for *absimilis* and the two species to be described later, but the trident sex mark in the male and the white patch reaching apex of hindwing in the female distinguish it from these.

Dr. Ledward has found the larvae feeding on several species of *Loranthus* and will shortly describe them. (The pupal duration at Burleigh Heads in early spring is about 33 days.) It is found along the Queensland coast and on Prince of Wales Island. It will no doubt be found in northern N.S. Wales.

The male clasps are very pointed.

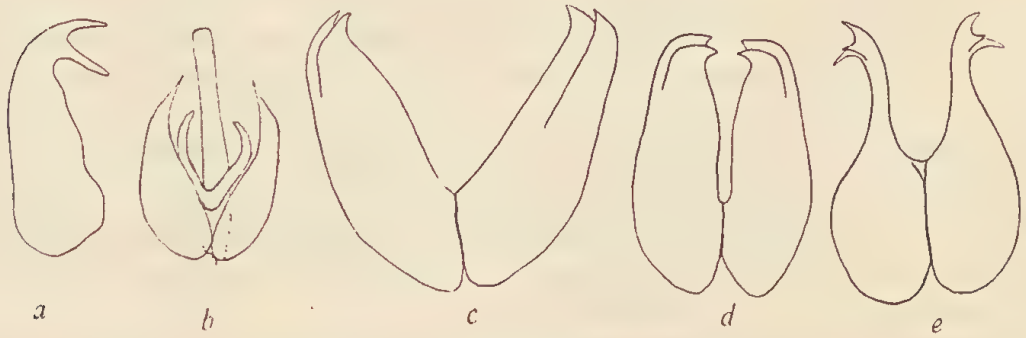

Figure 1.
Clasps of a, *helenita*; b, *margarita*; c, *absimilis* (Sydney); d, *persimilis* (Mackay); e, *consimilis* (Sydney).

Candalides absimilis Felder, 1862. (Figure 1c.)

The male of this species is uniformly blue above with very narrow black margins and no matter how it is viewed from above no sex scales can be seen. If, however, it is held before strong transmitted light, a trident mark can be seen on the forewing. The female is black above with a central white spot on each wing, that of hindwing not reaching apex. Base of both wings dusted with purplish scales. Underside more heavily marked than in *margarita*, but the terminal spots of hindwing usually absent.

The holotype male is in the Tring Museum, from Ash Island, received from A. W. Scott. It extends along the coast north to Brisbane; south of Sydney it is not so common and a few specimens have been taken in Victoria. I have bred it in my garden at Killara, near Sydney, feeding on the young leaves of *Cupania*. In 1922, the larvae were very common on the Richmond River, feeding on the leaves of *Cupania*, native *Wistaria*, and several other plants. At both these places I caught *absimilis* and *consimilis* on the same day.

The pupal duration of this species is peculiar. A larva from Killara pupated in December and the male did not emerge until the following September. Numerous larvae from the Richmond River, found in September, pupated in October and gave males and females in 17–23 days.

Candalides persimilis n. sp. (Figure 1d.)

The species is somewhat similar to the following in that it has the same type of sex mark on the forewing in the male. The colour is very different as also are the male clasps, which are very like those of *absimilis*.

Male. Upperside lilac with a narrow brown termen to both wings. Forewing with a central patch of dull sex scales and hindwing with a black spot near tornus. Female brown-black with a large central white patch and a few basal blue scales on forewing; a smaller white patch on hindwing, variable in size, sometimes absent. Underside similar to *absimilis*, but with a distinct black spot near tornus of hindwing.

This species in the male is quite a different colour from *absimilis* and also it has sex scales on the forewing as in *consimilis*. I have chosen as the type series thirteen males and seven females from a number caught at Mackay by R. E. Turner. During the long time he was there the only other species of this group caught by him was one female *margarita*. I have it from Cairns and Kuranda. Four males and two females from Byron Bay seem to be the same.

The male clasps are markedly different from *consimilis*, but somewhat close to those of *absimilis*. At the end they are cut off straight instead of being gently rounded as in *absimilis*.

Candalides consimilis n. sp. (Figure 1e.)

This interesting new species is generally smaller than *absimilis*, the termen of forewing slightly straighter and the tornus of hindwing slightly produced. It has a less rounded appearance.

The male upperside is a duller blue, the termen of forewing is broader black, especially between the veins, and extends towards a rather conspicuous patch of dull sex scales in the centre of the forewing. The termen of hindwing is also broader black and there are two or three conspicuous black spots near tornus. The female is black above with a distinct whitish central spot on forewing with blue scales below and towards the base, the hindwing has a variable central whitish spot in most cases entirely obscured with blue scales. Underside of both sexes similar to *absimilis*, with terminal black spots sometimes faintly indicated.

This species is no doubt in many collections under *absimilis*, but the sex scales and the remarkable genitalia readily distinguish it. The latter are so distinct that it is hard to believe they belong to the same genus.

The type locality will be my garden at Killara, near Sydney. Until this summer I had only caught one male, but had probably overlooked it. I have recently taken both in some numbers on the same day flying along the same flight track. I have also caught it at Stanwell Park and Narrabeen (without any *absimilis*). It is represented sparingly in the collection from Sydney to southern Queensland. Amongst a number of specimens caught at Ballina, only one was this species. I have males from Lawson, Blue Mountains, and from Lismore. Females seem to be rare.

The genitalia of this species are very different from the others. The clasps resemble a bulb with its dried stalk.

I hope I have accomplished the difficult task of differentiating between the above three species. With the series in the Museum there is not much difficulty in recognizing the three and the genitalia confirm this. Many more specimens are required to determine the range of the species.

It is possible that with other species of this genus, two or more species may be included under one name, as was the case with *C. erinus* more than forty years ago.

Arhopala amytis Hewitson, 1862.

Both sexes of this species were described by Hewitson and the female figured from specimens in the British Museum, with no more precise locality than 'Australia'. At the same time a small female was figured from Aru.

When examining the types, I was surprised to find that they did not agree with the race known in Australia as *amytis*, nor with the description given by Bethune-Baker,[3] 1903, in his fine monograph of the genus. I found that both had labels C.Y. and 50–95. On reference to the register I found these meant they had been collected by John Macgillivray at Cape York and registered in 1850. Other specimens from Cape York in London agreed with them. This fixes the type locality as Cape York. It is astonishing that Bethune-Baker did not notice this and one wonders if he ever looked at the types. He at the same time treated Cape York specimens as a variety.

A. cyronthe Miskin, 1890, described from two males from Cape York and Bowen, is a synonym. The Bowen locality is certainly incorrect.

The Museum has the typical race from Cape York, Thursday, Prince of Wales and Banks Islands.

A. amytis amphis, n. subsp. This is the race that hitherto has been considered the typical one. I have shown above that it is not so. The male is blue, somewhat similar to the typical race, but is slightly greener above and more shining, the termen of the forewing is broader and the apex considerably broader black. On the hindwing the

[3] Bethune-Baker.—*Transactions, Zoological Society of London*, xvii, 1, 1903, p. 33, pl. iv, figs. 9-9a.

termen is also broader black. The undersides are as variable as the typical race, but the green scales near the tail are very much restricted. The female is greener above and the black margins are broader. The underside is as variable as in the other races.

The type locality will be Mackay, where in May, 1935, I found it flying in large numbers, and we have it as well in quantity from Mr. R. E. Turner. I would also place here specimens from Townsville and the Cairns District. The four figures in *The Butterflies of Australia* were all taken from Mackay specimens. We have specimens more obscured on the underside than fig. 462 and more heavily marked than fig. 467.

A. amytis amydon, n. subsp. The male upperside is rich purple without the shining appearance of the two other races and the margins are very narrowly black. The female upperside is dull violet-blue, quite unlike the shining colour of the other races. On the underside this race is also very variable, and the green scales near the tail are extensive.

This is not such a brilliant race as the others and is easily distinguished by the colour of the upperside, especially in the female. We have a small series from Murray Island (type), two males from Darnley Island, and one male from Groot Eylandt. Probably the few specimens we have from Port Darwin will come here.

DESCRIPTION OF A LIBYAN DESERT LAND SHELL.

By Tom Iredale.
Conchologist, The Australian Museum.

Exiliberus jacksoni, nov. gen. et sp.

Mr. H. A. Longman, Director of the Queensland Museum, has forwarded a very interesting land shell for description. Five specimens were received from Corporal Kenneth Jackson, of the Queensland Museum staff, on active service in Libya, with the following note:

"Species of land snail from the Libyan Desert Plateau, Western Egypt. These animals are scattered amongst the limestone rocks and protect themselves by secreting a substance which forms a membrane inside the shell opening. Before sandstorms they anchor themselves to the rocks with the same secretion. What do they live on? I found this strange species in one isolated spot only."

The shells are comparatively large, globosely lenticular, upper and lower surfaces roundly convex, the periphery with a sharp pinched keel. Coloration cream. Whorls 4½, the first smooth, the succeeding ones coarsely sculptured. The earlier whorls are flattened, the antepenultimate more rounded, and the last descending towards the aperture half the depth of the whorl. The sculpture consists of very irregular radial closely packed ridges, crossed with a few faint concentric lines somewhat more notable on the last whorl, but sometimes these may become obsolete. Apparently due to their anchoring as noted above, new outer lips are formed curiously sandgrained, and these persist as browner, rougher ridges for a full quarter of a whorl, descending more steeply, with the number reaching thirty or more ridges. The undersurface is convex and sculptured similarly to the upper surface. The mouth is subcircular, the outer lip thickened but not reflected, the columella short, slanting, and thickly spread over the umbilical area, a thick glaze connecting with the outer lip. The measurements of the type are: Breadth, 46 mm.; height, 32 mm.; breadth of aperture, 22 mm.; height of aperture, 19 mm.

No Egyptian snail similar has been traced here in literature, and the figure given by Thiele in the *Handbuch*, p. 719, fig. 761, of *Iberus gualterianus* shows its general appearance. As the shell characters differ from those of *Eremina* and its associates in northern Africa, the strong keeling, sculpture and form being distinctive, the species is named *jacksoni* after its discoverer, and the genus *Exiliberus* introduced for its reception. This name is given to record the similarity to *Iberus*, but not as an indication of its close affinity, as the likeness may be due to convergence only.

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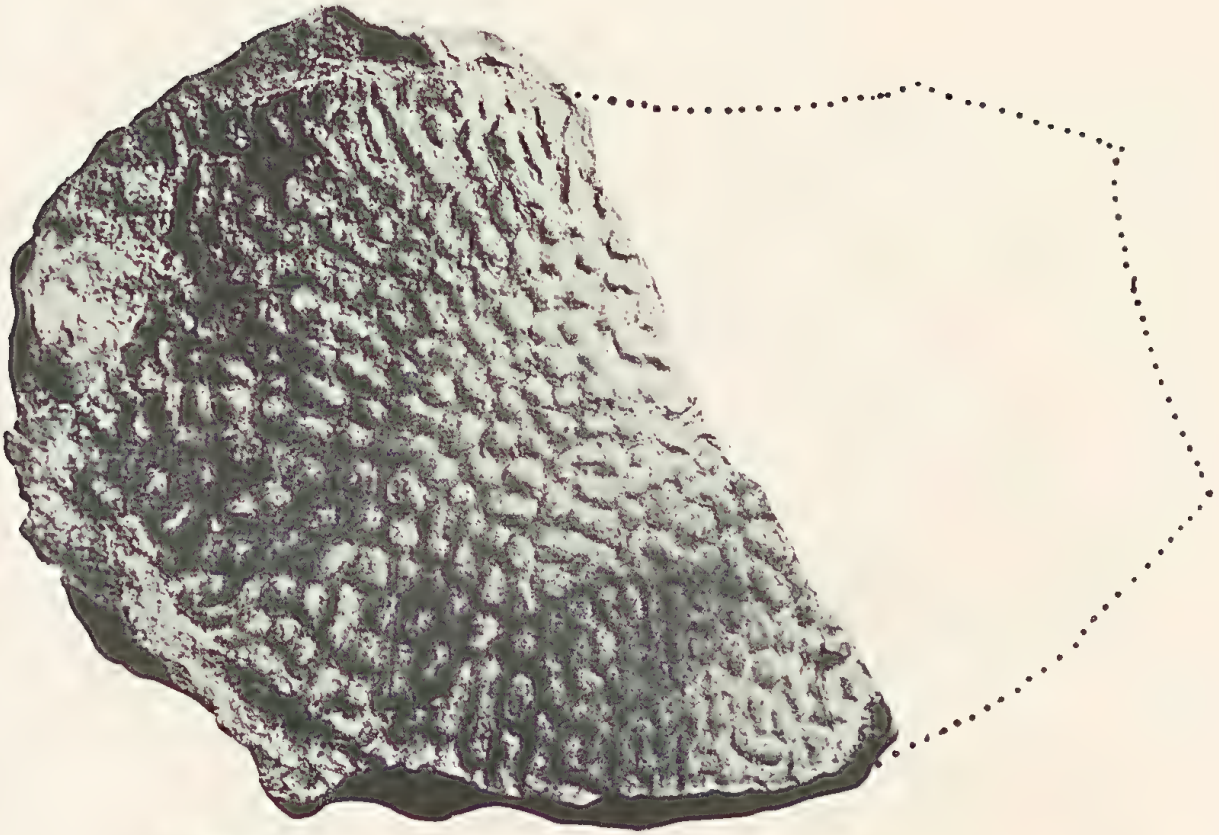

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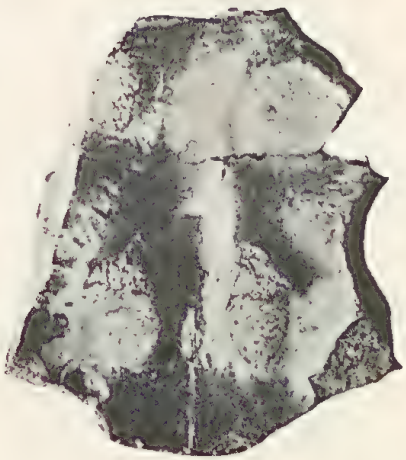

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AN ANALYSIS OF THE KNAPPED IMPLEMENTS FROM EIGHT *ELOUERA* INDUSTRY STATIONS ON THE SOUTH COAST OF NEW SOUTH WALES.

By Frederick D. McCarthy,
The Australian Museum.

(Figures 1–103.)

This study consists of an analysis of 5,716 knapped stone implements in the Australian Museum collection from the eight most important kitchen-middens along the south coast of New South Wales (Fig. 1), from Bondi to Merimbula, a distance of approximately two hundred miles. It is the second of a series of similar investigations on sites in this State from which reasonably complete collections are available. It is considered that any deficiencies in the collection from any one of the sites are covered by material from the remainder; thus, for example, cores and blocks are well represented from Port Kembla, *elouera* from Bellambi, and *bondi* points from a number of sites. That the collection is fully representative is indicated by the fact that it was gathered by a large number of collectors, the principal contributors including the Rev. A. J. Barrett, Miss Elsie Bramell, Messrs. C. Greenwell, F. D. McCarthy, O. B. Pryor and J. S. Rolfe, and the late R. Etheridge, Jr., A. E. Ivatt, W. W. Thorpe, and T. Whitelegge, from 1900 to date.

Analyses have been made by McCarthy (1941*a*) of a uniface pebble industry at Yamba and Crescent Head, Tindale and Noone (1941) of a flint hoard from Eucla, Western Australia, and N. A. and H. V. V. Noone (1940) of quartz implements from Ceylon. In this study the nomenclature used is descriptive, as far as possible, although native names are accepted in some cases, because they are non-committal and form a convenient terminology. The classification is based on the technique employed, and

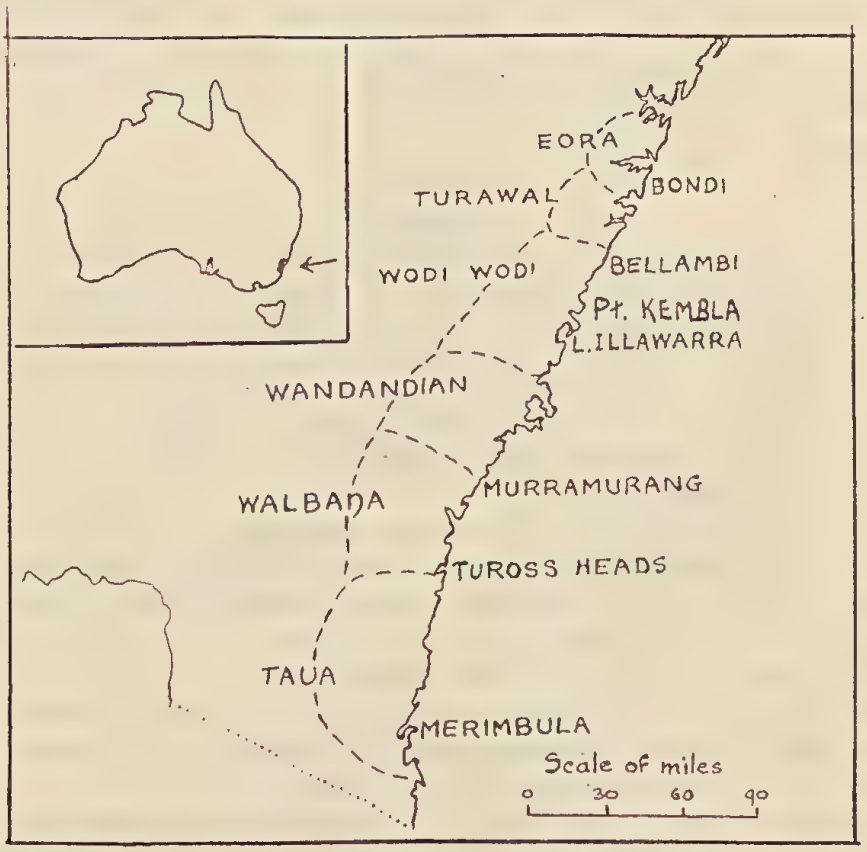


Fig. 1.—Map of the south coast of New South Wales, showing stations and tribes.

on the form and function of the implements. For want of any stratigraphical grouping, the specimens are treated as a whole, although it is probable that their production extends over a considerable period of time, during which there were changes both in the native population and in their methods of working stone. The aim of this analysis is to reveal the range of artefacts in the *elouera* industry, their nature, function and relative importance. Similar studies on sites throughout Australia will serve to bring into prominence the main features and cultural relationships of Australian lithic cultures, and permit us to differentiate local developments.

Literature.

References in early literature are confined to such statements as "the spear is fashioned to a point with a flint-stone or oyster-shell". Hunter (1793, p. 452) said that, on the Nepean River, a piece of hard stone was fixed in gum on the end of the spear-thrower, brought to a sharp edge, and used for making spears, but the type of flake so mounted is not known. The Port Jackson and Botany Bay natives hafted a shell on the end of a spear-thrower or short stick, and with it pointed spears, removed oysters from the rocks, cut cicatrices on their bodies, and employed it for other purposes (Phillip, 1789, p. 79; Hunter, 1793, p. 34; Collins, 1804, p. 358). More than a century had elapsed before any detailed work on the coastal sites was carried out, when Whitelegge discovered the Bondi, Maroubra and other workshops in 1900; in 1907 Etheridge and Whitelegge described the sites and their contents. In 1927 Doak and Doyle described the Boat Harbour and Quibray middens at North Cronulla, but mentioned only a limited number of the artefacts present. Towle (1930, 1935) published two papers on the *elouera*, in which he was mainly concerned with demonstrating that it was a scraper tool and not a chipped-back knife, as Thorpe and others asserted, and that material was the dominant factor in the production of asymmetrical flakes on the south coast and symmetrical flakes on far west sites in New South Wales. In 1928 Thorpe described various knapped implements from the Newcastle district, and Miss L. D. Hall analysed the artefacts from Morna Point, her classification being based primarily on shape. During 1931 and 1932 Thorpe described uniface pebble implements, flakes, edge-ground axes and knives, *worimi*, *elouera*, fish-hook files, coroids, and blocks from coastal sites, and in 1931 Turner discussed the use of the *elouera*. In 1941 McCarthy described two uniface pebble sites on the north coast of New South Wales, and during 1940–42 mentioned various artefacts of the *elouera* industry.

Sites.

The eight sites dealt with in this paper are kitchen-middens situated among the dunes fringing ocean beaches. They consist of deposits up to two feet thick on the dunes; on the sloping sides of the dunes are the stones, artefacts, shells and bones eroded from the midden. The deposits are undulating, and extend in some instances to basins between the dunes. Details of these sites are as follow:

Bondi.—The midden extended the whole length of the back of the beach, but it is now covered by a concrete roadway and promenade. It is only a short distance from the eastern shore of Port Jackson.

North Cronulla.—Two middens, one at Boat Harbour, twenty chains square, at the north end of the ocean beach, and the other one mile away on the shore of Quibray Bay. The latter consists of several basins almost surrounded by large dunes, and covers many acres, but the dunes have now covered a large portion of the deposit. It has been fully described by Doak and Doyle (1927).

Bellambi.—An extensive midden about one-quarter of a mile long, situated beside a creek, and near a lagoon in a marsh behind the dunes. Etheridge and Whitelegge (1907) stated that it was the largest of the collecting grounds.

Port Kembla.—A large midden and a small one on the northern side of Redhead Point, which overlooks the Five Islands, and is fringed by a sheltered beach. There is a small midden on the adjacent beach to the north.

Lake Illawarra.—Two middens on the north and south sides of the channel flowing across the beach to the sea at Windang, and scattered patches of midden along Seven Mile Beach extending northward to Redhead Point.

Tuross Heads.—A midden covering about two acres on a headland between Tuross and Coilah Lakes.

Murramarang.—A main deposit and several scattered patches of midden, almost as extensive as the Bellambi station.

Merimbula.—A workshop on a dune ridge overlooking the beach and the lagoon. It covers about one acre, and on it are an immense number of unused water-worn pebbles.

Normal aboriginal skeletons have been obtained at most of these sites.

In addition to these eight sites there are, throughout the area, numerous smaller middens and workshops on which the same types of artefacts occur.

Materials.

A wide range of siliceous materials (Harper, 1915) is represented, including chert, chalcedony, quartz, flint, jasper, latite, slate, quartzite, and porphyry, and silicified wood, tuffs, shales, grits, and Tertiary sands. From Bondi to Lake Illawarra the materials are strikingly varied, silicified wood being abundant at Bellambi, but from Tuross Heads to Merimbula coarser porphyry and silicified sands predominate. The sources of these materials are too numerous to be localized. Igneous intrusions are common throughout the area, and have been the cause of the formation of a widely varied group of metamorphic rocks suitable for knapping. There are porphyritic flows at Durras and Murramarang, and this material was commonly used on the far south coast. Deposits of water-worn pebbles occur in some localities, as at Nerriga, and form pebble beaches at Scarborough and Murramarang. Silicified wood occurs at Ulladulla and at the entrance to the Minnamurra River, among other localities. No doubt some local outcrops of stone were favoured for making artefacts, and stone from them traded between groups of natives, because a considerable proportion of the materials has been brought to most of the kitchen-middens along the south coast.

Technique.

The cores display convergent and irregular knapping, and parallel knapping is unusual. On the whole, the materials are so intractable that flakes were struck off the cores wherever possible, and the knapping face is irregular on a large number of globular and polyhedral specimens, but prismatic cores are well represented. A more or less flat striking platform was prepared by the removal of one or more flakes of the crust surface, and cores with one striking platform are in the majority. The knapping face is at an angle varying from 50° to 90° to the striking platform. On the edge of the latter are one or more projecting lips, which may be pointed, straight or rounded, and from each lip a ridge extends down the core between two flake scars. The knappers utilized these ridges in striking blades from the cores. The hammer blow was delivered haphazardly on or behind the lip—that is, anywhere from one side of it to the other on the striking platform of the core, as a study of the impact spots on the Bellambi *elouera* demonstrates: centre of butt, 102; thick margin side of butt, 90; thin margin side of butt, 19; thick lateral margin, 14; uncertain, 32.

Two techniques were employed in knapping. In the first method (Figs. 2*a*–*b*) the top of the flake scars, right along the knapping face of the core, was trimmed to eliminate the lips and projections and to enable the blow to be struck more easily on the body of the core; flakes from these cores have a plain platform, and the top of their outer face is trimmed. In the second method (Figs. 3*a*–*b*) the curved edges of the flake scars were delicately trimmed on the margin of the striking platform, and flakes from these cores have a faceted butt. The blow was usually struck behind a ridge on the knapping face, so that the outer margin of the butt platform of the flakes comprises the trimmed top edge of two flake scars separated by a ridge; the trimming extends to

long narrow spalls right across the butt platform of flakes and blades. Flakes produced by both techniques occur in all groups of knapped implements, including the *elouera* and *bondi* points.

The bulk of the flakes are asymmetrical, owing largely to the refractory materials, with odd symmetrical flakes and numerous irregular scraps; the majority have a plain butt, but the faceted butt is common. The inner platform angle of the flakes and blades varies from 90° to 130°, there being no consistency of any intermediate angle.

In knapping, the cores were either held in the hand, as the use of discoid and pebble cores indicates, or placed on an anvil stone. The cores demonstrate a lack of ability by the knappers to prepare them to produce long or symmetrical flakes and blades, except in the production of *bondi* points. Symmetrical flakes are common at Merimbula, where comparatively tractable materials were used, and in this connection it is interesting to note the scarcity of *elouera* at this site. Large flakes, especially those of the slice kind, are common at Tuross Heads, Murramarang, and Merimbula, where porphyry and silicified sands in large masses were available, in contrast to the smaller pebble cores and flake implements found between Lake Illawarra and Bondi. The *elouera* industry belongs to the blade group, as its characteristic implements, *elouera* and *bondi* points, indicate. Generally speaking, the knapper's aim was to strike from the core a blade suitable for use as an *elouera* or *bondi* point, the unsuitable flakes being used for diverse purposes, such as knives, burinates, end and concave scrapers, flake fabricators, and so on.

Towle (1935, pp. 124, 127–8, fig. 3) has asserted that the impact spot on the majority of *elouera* is not on the centre of the butt, but in our series the central impacts are approximately equal to those towards the thick or thin margins. The blow was delivered from (*a*) the thick side towards the middle or thin margin, (*b*) the thin side towards the middle and thick margin (a minority), or (*c*) through the centre of the butt towards the thin margin, medially, or towards the thick margin. Fourteen specimens have the impact spot along the thick lateral margin and are only suitable flakes picked out from the mass.

Trimming or secondary working was done by several methods. A direct-percussion technique was apparently employed for the bulk of the knapped implements, producing an even edge (apart from the serrated), generally worked from the cleavage or inner face. The trimming on the *elouera*, *bondi* points, and microliths is of a similar nature, although it varies on the *elouera* to a cruder percussion type of trimming. Pressure chipping must have been employed in fashioning the *bondi* points, on which the distal end is so fragile. The flake fabricators (*outils écaillés*), hitherto termed "button" flakes, were most probably employed for trimming and retouching, either held in the hand, or, to judge by the large number of the punch-like variety, placed between the hammer-stone and the implement being trimmed. McCarthy (1941*c*, p. 263) has already raised this point, while Malan (1942, p. 119) has suggested that they were fabricators in the Modderpoort industry of South Africa. On the south coast of New South Wales these flake fabricators are most abundant at the sites—Quibray and Bellambi—where *elouera* and *bondi* points are most plentiful, and it is possible that the trimming on the two latter implements was done with them.

Artefacts.

The artefacts dealt with in this paper comprise 489 cores, 176 core implements, 184 blocks, 2,142 normal flake and blade implements including 677 *elouera*, 2,340 *bondi* points, 142 geometrical microliths, 33 slices, 210 uniface pebble implements, and 2 biface pebble implements. Each group and the characters of several of the conventionalized types are analysed in Tables I–VII. It is realized that the figures have no absolute meaning, because the classification of some specimens is necessarily arbitrary, but it is believed that the ratios of artefacts revealed by the tables are reasonably accurate, and will be found to hold good. The analysis demonstrates the wide variety of tools in this industry, and the adequacy of the collection.

I. Coroid Implements.

	Bondi.	North Cronulla.	Bellambi.	Port Kembla.	Lake Illawarra.	Murramarang.	Tuross Heads.	Merimbula.	Sub-totals.	Totals.
Cores:										
One striking platform ..	—	10	67	98	7	1	17	19	219	
Pebble	—	3	26	5	—	7	—	—	41	260
Two striking platforms:										
Opposite	3	9	20	34	9	1	4	6	86	
Right angles	—	6	23	35	1	3	11	8	87	
Discoid	—	1	4	—	2	2	6	4	19	192
Irregular	—	—	8	23	—	1	4	1	—	37
										489
Core implements:										
Crown, straight-convex ..	—	6	1	16	1	2	1	2	29	
Keeled, straight-convex ..	—	—	8	10	1	5	2	—	28	
Concave	—	—	14	29	—	—	3	6	52	
Nosed	—	—	5	10	—	3	2	10	30	
Burinate	—	1	1	—	—	—	—	—	2	
Biface discoids	—	8	3	6	5	4	1	8	37	176

II. Uniface Pebble Implements.

End:										
Carefully trimmed ..	—	1	8	4	1	1	—	—	15	
Crudely trimmed ..	—	3	24	15	3	10	1	—	56	
Lateral	—	2	17	10	2	9	1	—	41	
End and lateral:										
Carefully trimmed ..	—	—	14	1	4	2	—	—	21	
Crudely trimmed	—	—	6	4	2	5	—	1	17	
Sumatra type	—	—	3	—	4	10	3	—	20	
Split pebble	—	4	20	1	4	5	5	—	40	210

III. Blocks.

Crown:										
Straight-convex	2	5	6	6	1	3	6	2	31	
Concave	4	3	4	10	—	2	10	4	37	
Nosed	—	—	5	6	1	2	2	1	17	85
Keeled:										
Straight-convex	—	3	16	6	2	2	1	2	32	
Concave	—	2	4	3	—	1	2	9	21	
Nosed	—	—	4	5	—	4	—	7	20	73
Worimi	—	1	—	—	1	3	7	2	14	
Karta	—	5	10	8	1	9	20	9	(63)	
Burinate	—	—	—	—	—	1	—	—	1	
End	—	—	3	—	3	—	2	3	11	26
										184

IV. Slice Implements.

One straight to convex trimmed edge	—	—	3	—	2	9	2	2	18	
Double side	—	—	—	—	—	1	—	1	2	
Concave and nosed ..	—	1	1	—	1	6	1	—	10	
Utilized	—	—	—	—	2	1	—	—	3	33

V. Normal Flake and Blade Implements.

	Bondi.	North Cronulla.	Bellambi.	Port Kembla.	Lake Illawarra.	Murramarang.	Tuross Heads.	Merimbula.	Sub-totals.	Totals.
Elouera, type 1	4	27	104	65	34	43	2	9	288	
2	1	8	57	19	15	14	1	4	119	
3	4	6	94	87	43	32	—	4	270	677
Scrapers:										
Side	7	42	27	32	43	22	13	21	207	
Side and end	—	6	4	5	8	4	—	4	31	
Double side	—	18	6	6	8	3	6	1	48	
Double side and end	—	2	—	6	1	—	—	19	28	314
End:										
Straight	2	5	3	1	2	4	3	10	30	
Convex	11	16	13	4	6	6	5	12	73	103
Butt-end	27	3	12	—	10	5	4	13	66	
Concave	1	3	7	5	4	4	5	5	34	104
Concave:										
Lateral	3	8	20	12	2	15	18	54	132	
End	1	2	8	1	4	4	5	8	33	165
Nosed	—	2	15	5	3	8	4	32	—	69
Utilized	2	5	17	6	5	9	—	10	—	54
Knives	10	40	63	40	33	18	29	17	250	
Serrated	2	11	22	17	18	22	9	8	109	359
Smoothed	1	6	6	5	5	—	—	—	—	23
Piercers	1	2	8	—	1	5	10	6	—	33
Burinate, marginal:										
Vertical	3	4	3	1	1	1	1	—	14	
Transverse	1	3	2	2	1	2	1	—	12	
End	—	—	—	—	—	—	1	—	1	
Scaled	—	4	1	1	6	1	—	—	13	40
Flake fabricators:										
1 margin	1	10	13	9	6	—	—	—	39	
1 margin and 1 end	—	5	1	—	3	1	—	—	10	
2 margins	—	10	5	12	1	—	2	—	30	
2 margins and 1 end	—	20	11	—	—	—	1	—	32	
4 margins	2	5	—	2	—	—	—	—	9	
Punch-type	2	22	21	23	8	5	4	—	85	205
										2,142

VI. Bondi Points.

Type:										
Narrow segment	273	523	52	24	279	165	98	12	1,426	
Broad segment	173	285	35	13	146	155	92	15	914	2,340
Conformation:										
Left	264	483	55	22	260	201	116	16	1,417	
Right	176	325	32	16	164	125	74	11	923	2,340
Partly blunted:										
1 margin	44	59	18	9	52	37	19	9	246	
1 margin and butt	13	15	4	—	5	19	12	1	69	
1 margin and faceted butt	22	34	12	3	24	37	28	6	166	
Fully blunted:										
1 margin, 1 edge	202	407	32	15	237	154	94	6	1,147	
1 margin, 2 edges	115	259	18	7	89	73	33	5	599	
2 margins	24	38	3	2	20	4	3	1	95	
3 edges	3	8	—	1	4	1	1	—	18	2,340
Point:										
Trimmed all round	25	51	8	1	11	3	4	—	(101)	
Butt:										
Plain	214	523	63	25	266	164	85	13	1,363	
Faceted	55	101	6	4	46	26	28	6	271	

VI. Bondi Points.—*Continued.*

	Bondi.	North Cronulla.	Bellambi.	Port Kembla.	Lake Illawarra.	Murramarang.	Tuross Heads.	Merimbula.	Sub-totals.	Totals.
Butt blunting:										
Rounded, 1 edge ..	96	100	8	6	77	60	42	3	392	
Rounded, 2 edges ..	78	74	7	2	35	45	20	4	265	
Straight	4	8	1	—	3	2	10	1	29	2,340
Thin margin:										
Used	74	81	8	5	60	22	23	2	(275)	
Size:										
0–2 cm.	193	260	19	3	80	29	17	6	607	
2–3 ,, ...	213	459	53	20	255	174	89	12	1,275	
3–4 ,, ...	30	80	13	12	68	101	74	5	383	
4–5 ,, ...	4	9	2	3	21	18	10	4	71	
5–6 ,, ...	—	—	—	—	1	2	—	—	3	
6–7 ,, ...	—	—	—	—	—	1	—	—	1	2,340

VII. Microlithic.

Angular:										
Trapezoid	4	5	—	3	5	2	1	2	22	
Crescent	6	29	3	—	7	1	6	6	58	
Equilateral	1	7	1	—	—	1	2	—	11	
Isosceles	—	10	—	—	—	—	1	1	12	
Scalene	1	6	2	—	2	9	4	2	26	
Rectangular segment ..	—	1	1	—	—	—	—	—	2	
Discoid	—	8	2	—	1	—	—	—	11	142
Microlithic size (included in flake and blade totals):										
Abrupt trimmed blades ..	4	16	2	—	4	—	—	—	26	
Elouera	—	9	16	17	6	—	—	—	48	
Scrapers:										
Side	4	13	3	8	12	1	—	4	45	
Side and end	1	8	—	2	3	—	—	1	15	
Double side	—	8	4	—	1	—	—	—	13	
End (thumbnail)	17	20	14	1	4	2	1	5	64	
Butt end	11	—	—	—	—	—	2	3	16	
Concave and nosed ..	5	3	2	4	1	—	2	5	20	
Utilized	—	—	8	—	—	—	—	—	8	
Knives and serrated ..	1	9	15	8	8	—	2	—	44	
Piercers	—	—	1	—	—	—	—	—	1	
Burinate	—	6	2	2	4	1	2	1	18	
Battered:										
Punch	14	19	6	3	2	1	—	—	46	
Others	4	20	4	9	3	—	—	—	45	409

Coroid Implements.

Cores.

The cores are formless on the whole, and have been classified according to the number of striking platforms.

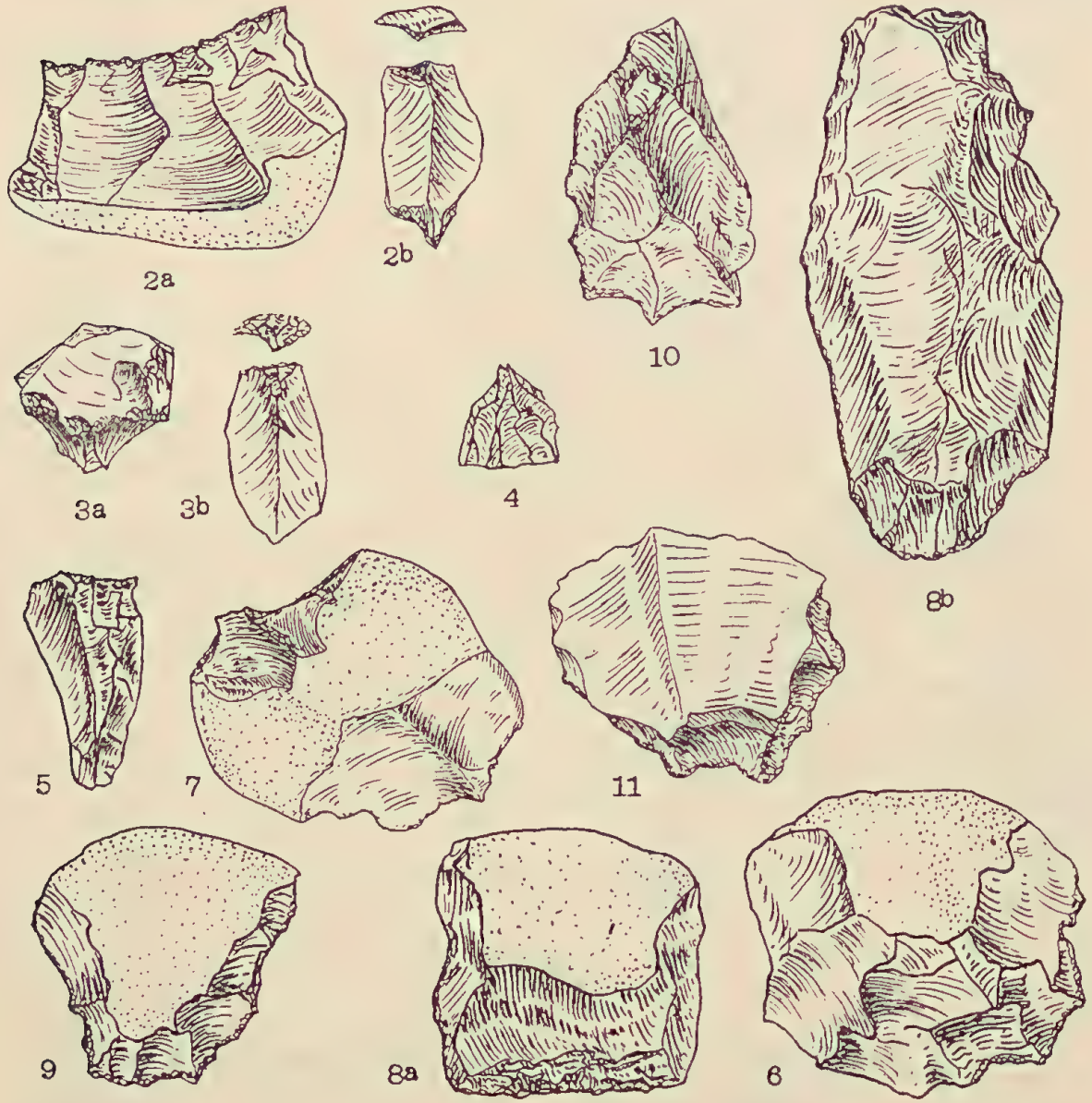
1. *One striking platform* (Figs. 2*a*, 32).—The distal end is either rounded pebble surface, fractured and uneven, or, on a minority, has a sharp unused edge at the end of two knapping faces.[1] On some examples it is battered, indicating that the core has either been placed on an anvil stone or used as a fabricator. The shape of the striking platform varies from circular to oval, triangular to rectangular, and its edge from straight to convex. The cores range from prismatic to irregular forms, the knapping

[1] Along this edge on a few cores flakes have been struck from both knapping faces in a skilful manner.

face and striking platform being the essential features, and a conventionalized shape, such as the conical type, of no importance. There are only six examples of the conical type in the collection, but it is more common as a pyramidal core (Fig. 4) among the microliths, there being fifteen specimens of the latter from the sites between Bondi and Lake Illawarra.

2. *Two striking platforms.*—(*a*) *At opposite ends*: A prismatic type (Fig. 5) in which a flake has been removed, or a flat crust surface utilized, at each end to form the opposed striking platforms. The majority are knapped longitudinally, others transversely.

(*b*) *At right angles*: One striking platform is made in the normal manner, and a negative flake scar on the edge of the core forms the second striking platform at right angles to the first.



Figs. 2*a*-8*b*.—2*a*, Core with plain striking platform, and trimming along top edge of knapping face. E.36660, Bellambi. 2*b*, Flake with plain butt struck from these cores. E.36660, Bellambi. 3*a*, Core with trimming on edge of striking platform. E.50404, Singleton. 3*b*, Flake with faceted butt struck from these cores. E.50280, Lake Illawarra. 4, Pyramidal core of microlithic size. E.43874, Quibray. 5, Prismatic core. E.41662, Tuross Heads. 6, Core with semi-discoidal edge knapped from both surfaces. E.43060, Bellambi. 7, Core, with burinate-like projection. E.45098, Bellambi. 8*a*-*b*, Uniface pebble implements. *a*, Trimmed on both ends and side. E.41250, Redhead, Port Kembla. *b*, Split-pebble, tranchet type. E.43385, Seven-Mile Beach, Lake Illawarra. 9, Block, crown, nosed. E.36742, Bellambi. 10, Block, keeled, concave and nosed, tranchet-shape. E.39107, Bellambi. 11, Block, keeled, nosed. E.38836, Murramarang. ⅔ natural size.

(c) *Discoidal*: This type (Fig. 6) has a discoidal or semi-discoidal shape and margin, and, along the latter, flakes have been knapped alternately from both surfaces. It is an uncommon type in the industry.

3. *Pebble cores.*—Flattened oval pebbles knapped at one end, or on a lateral margin. One variety has one striking platform and a knapping face, another is knapped from both surfaces alternately; thus the pebble core combines the characteristics of the single-platform and discoid types. The edge is often sinuous, and some have undoubtedly been used as implements, one from Quibray having an even convex edge showing obvious signs of use. Six from Murramarang are laterals, and one an end type with a carefully trimmed striking platform. The Port Kembla series indicate that they are primarily cores. The materials generally are coarser than those of the other cores. It should be pointed out that, although most of the cores were originally water-worn pebbles, and the majority are lumpy in form, this variety was treated in a special way by the knappers and is therefore differentiated as a pebble core.

Remarks.—Generally speaking, the cores are up to 14 cm. long, and of irregular shape. Prismatic examples are smaller on the average, being up to 8 cm., the discoids up to 9 cm., and the pebble type up to 15 cm. long.

There is a close relationship between the sizes of the cores and the number of points at various sites; thus at Quibray a large percentage of the cores are small and suitable for producing the *bondi* points so abundant at this site, while at Port Kembla the cores are larger on the average and points are scarce.

The tables show that cores with single striking platform were preferred, and their total number is slightly greater than those with two or more platforms. Discoid and conical cores are rare, but pebble cores are common. Tortoise cores are absent.

Cores used as implements.—These implements comprise two main groups, the crown and the keeled or carinate, each of which has been subdivided according to method of use into three varieties with straight to convex working edge, concave, or concave and "nosed". Table I shows that a large number of the core nuclei were in common use as steep and slope-faced scrapers and choppers, either on one lateral margin, end and lateral margins, or on both lateral margins. There are few coroids apart from these nuclei and all have been dealt with as one series. The working edge is often step-chipped and may show considerable evidence of use.

A large number of the core implements are keeled, especially those with a concave edge on a step-face. Two specimens are of the tranchet type, with a median ridge, trimmed lateral margins and end; one from Port Kembla is 7 cm., and one from Murramarang is 12 cm. in length.

The concave-edged core implements form a most serviceable set of tools for shaping curved surfaces, because of the strong edge supported by the body of the core in use. This also applies to the "nose", which is stouter and stronger than on the flakes. The concaves range from ·75 cm. to 2 cm. in width, although the majority are about 1 cm. wide. Double and multiple concaves separated by untrimmed keeled projections are common. Some of the concaves are worked back under the edge of the knapping face on the core. Edges with a series of small notches form one or more margins of some examples. The exceptionally large number of concave coroids from Port Kembla may be explained by the excellent series of coroids represented in the collection from this site.

One specimen from Tuross Heads is a small conical core, with a number of deep and shallow concaves separated by trimmed "noses". One interesting type has its distal end in the form of a rounded "nose" without concaves on each side. Among the specimens from Port Kembla one has a rounded face and edge 2 cm. wide, projecting 2 cm.; one has a straight edge, 1·25 cm. wide, projecting sharply; one has a similar edge worked back considerably by use, and one has a curved lip 1·5 cm. wide. Examples from other sites bear similar projecting working edges (Fig. 7) suitable for graving, which are closely related to the burinate edge. In size they have a similar range to the cores.

Pebble Implements.

1. *Biface.*—Only two examples, one from North Cronulla, 17 cm. long, trimmed along both lateral margins and one end, with anvil marks on one surface, and one from Bellambi, 7 cm. long, of a similar type, but much weathered on one surface. They are probably axe-blanks.

2. *Uniface.*—Although these are classified in the same way as the Yamba and Crescent Head series (McCarthy, 1941*a*), a distinction has been made between the carefully trimmed and crudely flaked examples in each group, the respective numbers of which are shown in Table II. The crudely flaked examples are probably choppers, and they are characterized by a thick steep or slope face, and a working edge which may be from straight to convex (on the majority), notched, concave, or nosed. The carefully trimmed ones appear to be *sumatras* in the making, although they were no doubt used as partially finished tools; many of them are thinner than the crudely flaked variety and are, therefore, scrapers rather than choppers. Features worth noting on examples of the various groups are as follows:

(*a*) *Working edge on one lateral margin.*—One from Tuross Heads is trimmed partly along one edge, and partly along the other edge, of the one margin.

(*b*) *Working edge on one end.*—The natural outline is preserved on the majority of the specimens. One from Bellambi has two straight lateral margins meeting in a point at the end. A large example from Bellambi is a blackish-grey pebble, with a wide concave in the middle of the trimmed end, and a straight edge on each side separated from the concave by an untrimmed peak. It is 17·5 cm. long, and was figured by Thorpe (1932, pl. xxxi, fig. 6).

(*c*) *Working edge on one end and on one or both lateral margins.*—The carefully trimmed unilateral and bilateral examples strongly suggest stages in the making of a *sumatra*. In the crudely flaked series three have a semi-discoid edge, steep face, and rounded noses wider than long; they are from 6 to 9 cm. long. One (Fig. 8*a*) from Port Kembla is thick and steep-faced, has two trimmed ends at right angles to the front marginal edge; the three margins are heavily worked and slightly concave, and it is 7 × 6 × 4 cm.

(*d*) *Split pebbles trimmed on edge of cleavage face.*—Thorpe (1932, pl. xxx, fig. 2) has figured a large pebble, 22 cm. long, from which a slice has been removed over two-thirds of its surface, which illustrates well the split-pebble or quartering technique. The impact spot may be on one end (twelve from Bellambi) or on a lateral margin (six from Bellambi). The edge trimming is slight on most specimens, and is on one end, lateral margin, or end and lateral margins as with the core type of uniface pebble implements; one specimen from Bellambi, 13 cm. long, is trimmed all round its periphery to form a *sumatra*, but this variety is rare among the split-pebble implements. A characteristic feature of the group is the extensive, flattish cleavage surface in contrast to the worked, convex surface of the true *sumatra*. An unusual pick-like example (Fig. 8*b*), with a convex blade at the distal end, was found on Seven Mile Beach.

One from Quibray has two trimmed lateral margins, and another a convex edge at each end. One from Murramarang has slight polishing or smoothing from use on both faces of the working edge. Concaves and "noses" appear on several specimens.

(*e*) *Sumatra-type.*—All oval in shape, and a small series in size. One from Lake Illawarra entrance is 21 cm. long, and is the largest of the series. Most of them are carefully trimmed.

Remarks.—Concave and projecting convex edges are common on the uniface pebble implements, as are edges with a series of shallow notches. The concaves range from 1 to 6 cm. wide, and are, as usual, often combined with "noses". Some of the latter are narrow and peaked, others are broad and rounded (Fig. 8*c*), ranging from 2 to 5 cm. wide, the majority being from 2 to 3 cm. In the Bellambi series only seven specimens show percussion use on the butt or lateral margins, and one has a series of shallow anvil pits on one surface. In shape the uniface pebble implements are mostly from oval to round, some being rectangular, and of various thicknesses and widths. A

number of examples are broken straight across in approximately the middle to form the *hache courte* of Indo-China.

Table II shows that the end type predominates at these eight sites, the lateral, end and lateral, and split-pebble varieties being equal, and the *sumatra*-type in the minority. Uniface pebble implements appear to be scarce at North Cronulla, Tuross Heads, and Merimbula, but none were collected at Bondi by Etheridge and Whitelegge, and it is not possible to say whether they were common or not at this site.

In size the uniface pebble implements form a relatively small and light series; the majority are between 6 and 13 cm. long, with a few examples up to 22 cm.

Knapped Implements.

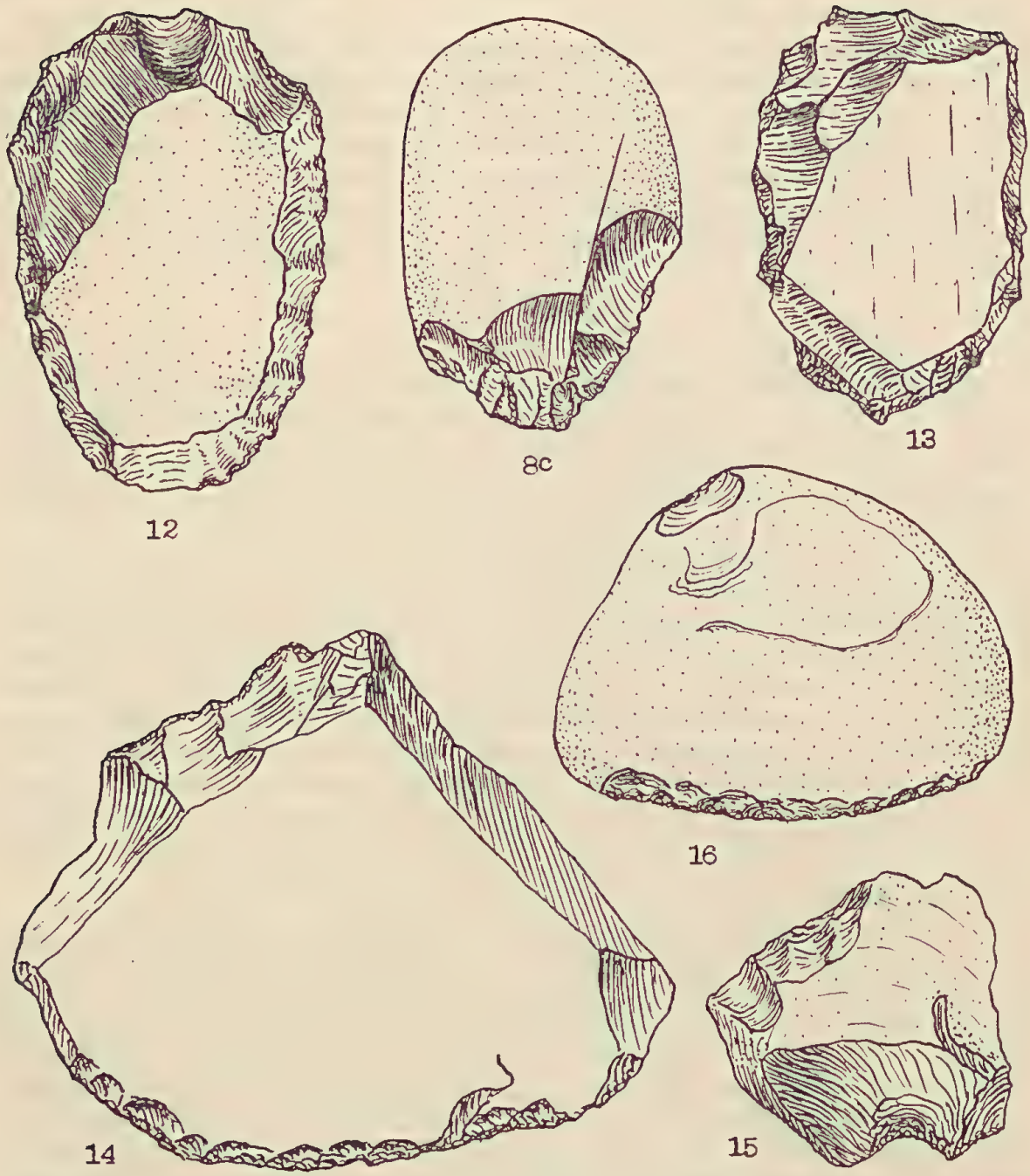
Blocks.

The blocks are distinguished from the coroids because they are knapped or quartered off larger pieces, and from the normal flake and blade implements because of their lumpy irregular nature. Like the coroids, they form two main groups, the crown and keeled or carinate, subdivided according to use, comprising straight to discoid, concave, concave and nosed, or burinate working edges; they were also used as fabricators. They are steep and slope-faced implements as a rule.

It is difficult to differentiate the *karta* as a distinct type from the description given by Tindale (1937, p. 48); they are essentially crown or carinate blocks, knapped haphazardly and not by a definite technique. McCarthy (1941*a*, p. 23) has defined the *karta* from Yamba and Crescent Head as split-pebble implements trimmed on the edge of the crust surface from the cleavage face (Fig. 12), and there are sixty-seven specimens of this type from the eight south coast sites. The Tuross Heads series of twenty specimens comprises steep-faced semi-discoids, discoids, end and side, and lateral trimmed margins of the notched type. One rectangular example has a broad concave, 5 cm. wide, and is trimmed on two lateral margins and one end. Five from Bellambi bear "noses" and pointed projections suitable for piercing, with concaves between; they are trimmed on various margins. One interesting type has its distal end in the form of a rounded "nose" without a concave on each side.

1. *Crown.*—In the Bellambi series four are semi-discoidal and four are discoidal to oval (Fig. 13). A discoid specimen from Murramarang has reversed trimming, half-way along one edge and half-way along the opposite edge of one margin. A tongue-shaped specimen from the same locality is trimmed along the two lateral margins and end, and is 5·5 cm. long. Some of the discoid and tongue-shaped blocks resemble the *arapia*. The concave (Fig. 15) and "nosed" (Fig. 9) series from Bellambi include discoid, semi-discoid, triangular and elongate examples. One of the semi-discoids bears three concaves from 2 to 3 cm. wide, and three trimmed "noses" (two of which are pointed). The triangular specimen has two concaves 3 cm. wide and one 1·5 cm. wide, with one "nose". Some of the concaves are only ·5 cm. wide. The "noses" are up to 2 cm. wide. Similar remarks apply to the series from the other seven sites.

2. *Keeled or carinate.*—The specimens do not conform to a uniform type, but are, on the whole, irregular in shape, which may be short and squat, elongate, rounded, or rectangular. One from Bellambi is of the tranchet type (Fig. 10); it has a longitudinal median ridge, triangular section, one trimmed lateral margin, bearing a concave, and joining the distal end, which bears two concaves separated by a pointed nose, there being another nose on the corner; it is 6 cm. long. There is also a smaller one of a similar type, which is almost circular and "nosed". One from Merimbula is 10 cm. long and has one trimmed lateral margin, and another one, 15 cm. long, is bat-shaped, tapering from butt to distal end, with a "nosed" corner and one trimmed margin. Those from Bellambi bearing concaves (1 to 2·5 cm. wide) are from discoid to oval in shape, and 4 to 6 cm. long. On one specimen is a set of three concaves each 1 cm. wide, and an elongate example bears five concaves (1 to 2 cm. wide) and two sharp "noses". An unusual example from Merimbula is a rostro-carinate, 6 cm. long.



Figs. 8c, 12-16.—8c, Uniface pebble implement. Trimmed on end, with broad nose. E.39053, Bellambi. 12, *Karta*. E.49618, Lake Illawarra. 13, Block, oval, edge trimmed all round. E.33703, Murramarang. 14, Large triangular slice. E.49617, Murramarang. 15, Block, crown, concave edge. E.37639, Bellambi. 16, Slice. E.33257, Murramarang. ⅔ natural size.

A common block type (Fig. 11) has a long, flat striking platform as its butt, opposite which is a convex trimmed edge often bearing concaves, "noses", and piercers combined. On the narrow examples the butt is as wide as the cleavage face, and they have been classified with the keeled group; there are three from Murramarang and six from Bellambi.

3. *Worimi*.—Those from Tuross Heads resemble closely the Anna Bay type (figured by Thorpe, 1928, pl. xxviii); all are knapped blocks, 7 to 16 cm. long, triangular in section, made of grey porphyry, and one has a well used "nose" at one end. One from Quibray is 12 cm. long and is a coroid, and two from Murramarang are 9·5 cm. long. Table III shows the *worimi* to be an uncommon implement at these eight sites, especially from Bondi to Lake Illawarra, where refractory materials were used, and where

lateral uniface pebble implements are common; on the other hand, pebble implements are uncommon at Tuross Heads and Merimbula, and *worimi* are best represented from these two sites and Murramarang, where porphyry was used. It appears, therefore, that *worimi* were made on the coast of New South Wales mainly where material is present from which large blocks may be struck, as at Anna Bay (porphyry), Newcastle district (chert), Murramarang to Merimbula (porphyry), otherwise uniface pebble implements, more especially the lateral-edged variety, were used, as McCarthy has already suggested (1941*a*, p. 25).

4. *Burinate.*—A general discussion of burinates, and the reasons for the use of the term, is given in the normal flake and blade section of this paper.

5. *Fabricators.*—The only locality well represented is Port Kembla and, of the ten examples, seven are battered on opposite and roughly parallel margins and three are of the punch-type.

In size, the blocks are up to 10 cm. long, being smaller on the average than the coroids.

Slice Implements.

There is no hard and fast line of demarcation between the slice implements and the normal flake and blade group. The slices are differentiated because of their great length and width compared to their thickness, being very large and comparatively thin. They are utilized rather than specialized tools.

Those from Bellambi have their margins gashed where large flakes have been removed, and bear both convex and concave working edges. One is 19 × 10 × 4 cm., with two serrated margins scaled on both facets of the edge. They are more numerous at Murramarang than elsewhere in the material dealt with in this study; one is oval with a semi-discoid trimmed edge, one has four concaves, one has a concave on its butt end, and one (Fig. 16), triangular in shape and 12 cm. long, has a long convex edge trimmed from the cleavage face along the edge of the opposite crust surface; they are 8 to 15 cm. long. Four from Tuross Heads are 10 to 11 cm. long; two have notched edges, one has several concaves, and one a convex trimmed margin. A large triangular-shaped slice from Murramarang (Fig. 14) has a trimmed convex margin 17 cm. long, and bears concaves on a trimmed margin adjoining the pointed butt.

Table IV shows that slice implements were unimportant in the industry, and were common on the four most southerly sites where the porphyritic material predominates.

Normal Flake and Blade Implements.

This group is the most varied in the industry. It comprises four main divisions—scrapers, cutters, burinates, and fabricators—and the varieties in each of these groups have been classified according to their use. The *elouera* forms a special group because it is a combination tool.

1. *Scraping and Cutting: The Elouera.*—A glance at Table V will demonstrate the importance of the *elouera* in this industry. At Bellambi, for example, there are 257 *elouera*, 288 normal flake and blade implements, 87 points, 9 geometrical microliths, 92 uniface pebble implements, 4 slices, 52 blocks, and 180 coroids.

Our definition of the *elouera* is more restrictive than that of Towle (1930, 1935), who regards all asymmetrical flakes with scraper retouch on the thick margin as *elouera*. We prefer to limit the term to those which have scraper-trimming or use on one or both edges of the thick margin, and cutting use on the thin margin. The *elouera* is thus a combination scraper-knife tool. Some exceptions, however, without thin edge use, especially those trimmed on both edges of the thick margin, are so obviously *elouera* that they have been included in this group, but most of the asymmetrical blades lacking this dual use have been classified as scrapers or knives, as the case may be. The high percentage of dual-purpose *elouera* indicates that it was an all-round tool used both in the fingers and also possibly embedded in gum on a handle or spear-thrower in a similar manner to the *tula* of the interior. Mr. H. V. V. Noone has informed me that he has found *elouera*-like flakes mounted as adze-flakes on specimens in the Western Australian

and South Australian Museums. It is interesting to note that the *elouera* as a whole exhibit secondary uses which combine the functions of the other flake and blade implements, including carinate and concave scrapers, "nosed" gravers, piercers, burinates, and punch-type flake-fabricators. The use of the *elouera* as a burinate illustrates the diversity of purposes served by this tool, and three varieties are present in the 16 examples which exhibit this character.

An analysis of the characters of 257 *elouera* from Bellambi resulted as follows:

Conformation: Left trimmed, 106; right trimmed, 108; uncertain, 43.

Ridges: Curved, 96; straight, 60; multiple, 101.

Thin margin use: Knife, 102; saw, 76; scraper, 21; faint or plain, 58.

Thick margin use: Trimmed from both faces, 133; from inner face, 102; from outer face, 22.

Impact spot: Thick margin side of butt, 90; middle of butt, 102; thin margin side of butt, 19; lateral margin (thick), 14; uncertain, 32.

Size: 0–3 cm., 65; 3–4 cm., 139; 4–5 cm., 47; 5–6 cm., 1.

Attention should be drawn to the agreement of right and left trimmed specimens, the comparatively even distribution of ridges on the outer surface, and the inconsistent position of the impact spot, features which demonstrate that a specialized technique was not employed to produce the characteristic asymmetrical blade used, but instead, suitable pieces were picked out of the flakes knapped, and utilized; in this connection it might be mentioned that a low percentage of trimmed flakes is typical of *elouera* industry sites. The analysis also reveals that a slight majority is trimmed from both faces along the two edges of the thick margin.

The *elouera* may be subdivided into three major varieties, of which two are approximately equal in occurrence, but the third, which might be termed the standard or ideal form, is the most uncommon. Their characteristics are as follow:

i. Lateral margin trimmed on one or both edges, butt and distal ends untrimmed (Fig. 17).

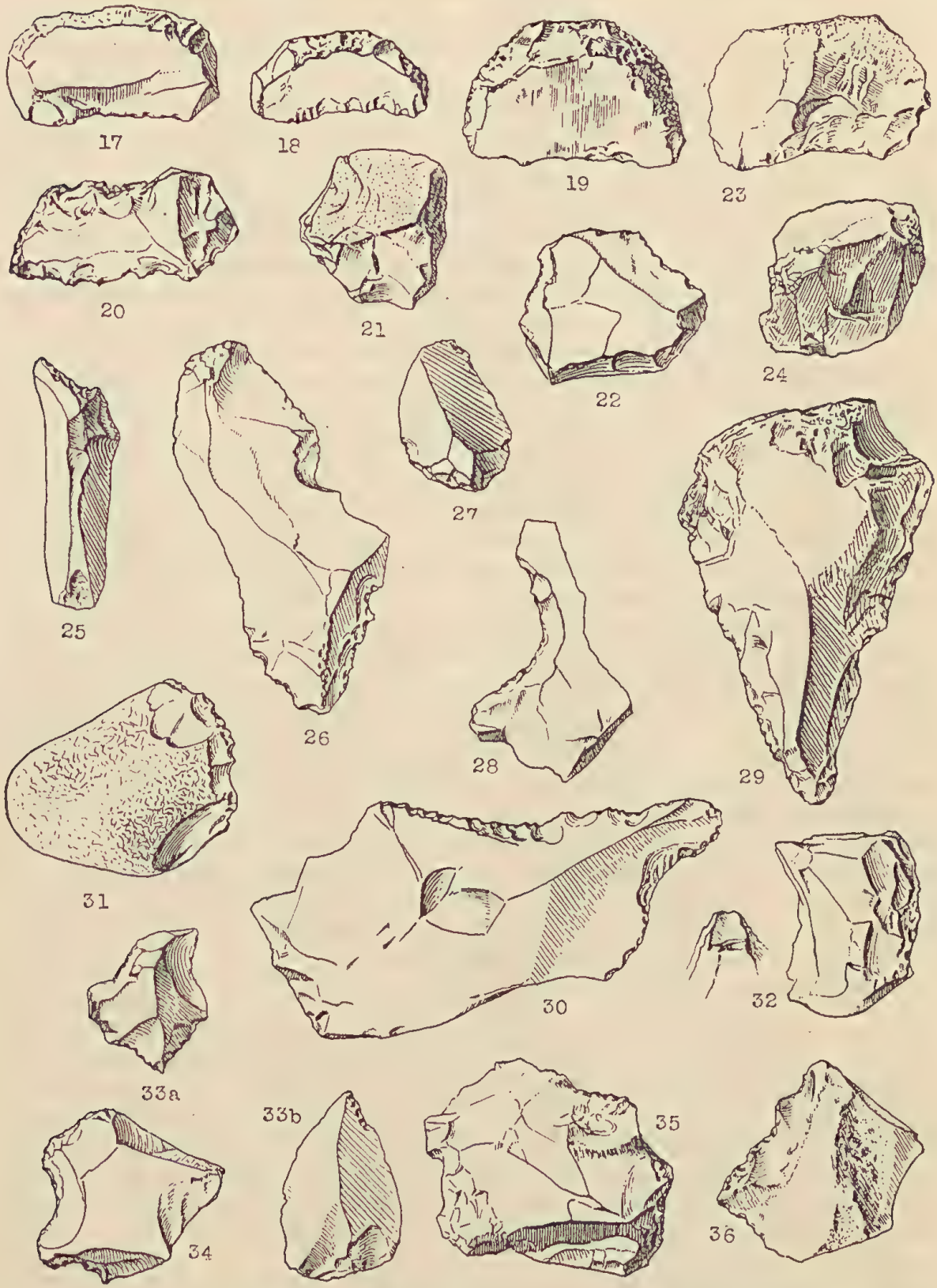
ii. Lateral margin wholly or partly trimmed on one or both edges, distal end often crescentic and pointed, butt untrimmed (Fig. 18).

iii. Whole of lateral margin, including butt, trimmed, crescentic in shape, and often pointed at both ends. Ideal type, of orange-segment shape (Fig. 19).

The shape of *elouera* varies considerably. The thick lateral margin may be straight or irregular, but is generally crescentic, and the thin margin ranges from concave to convex, but is often straight. The majority are elongate blades, but others are approximately quadrangular and rectangular, being straight at both ends, or triangular. A concave end-scraper edge occurs on six examples from Bellambi, and concaves are not uncommon on the thick lateral margin of *elouera* at this site; one has two concaves, worked from opposite faces to form an S-like end. Saw-like edges are common on the *elouera* from Lake Illawarra, and several thin margins of this nature on examples from Merimbula suggest rugged use. One from Lake Illawarra has a notched edge with several sharply pointed piercer-like projections, and one from Tuross Heads has a notched scraper edge on the thin margin. *Elouera* are scarce at Tuross Heads and Merimbula.

2. *Scraping.*—Table V shows that scrapers of many varieties were employed and form an integral part of the *elouera* industry. The discoid is practically absent, its nearest approach being the tongue-shaped variety common at Merimbula. Side, end, and concave varieties predominate, while side and end, and double side scrapers are uncommon; the side and end variety is well represented among the *elouera*. Ridged and flat forms occur in every variety, and the high crown or polyhedral forms are included in the blocks.

(*a*) *Side*: An irregular series of normal type. One from Merimbula is of quartz. Two of *elouera* form have a scraper edge on the thin margin. Some may be termed abrupt trimmed blades. On two specimens the edge has been worked back into the inner face. In the Bellambi series 13 have a straight edge, 9 convex, and 5 slightly concave.



Figs. 17-36.—17, *Elouera*, variety i. E.43858, Tuross Heads. 18, *Elouera*, variety ii. E.32054, Boat Harbour. 19, *Elouera*, variety iii. E.36789, Bellambi. 20, Blade with serrated edge. E.39137, Bellambi. 21, Double side scraper, pointed. E.34478, Tuross Heads. 22, Butt-edged end scraper. E.32169, Bellambi. 23, Flake fabricator used on two opposite lateral margins. E.39136, Bellambi. 24, Flake fabricator of punch-type. E.49377, Bellambi. 25, Oblique trimmed blade, with concave edge. E.50284, Lake Illawarra. 26, End scraper, ogival-shaped trimmed end. E.38963, Lake Illawarra. 27, End scraper, ridged, steep-faced E.49374, Bellambi. 28, Concave scraper. E.39891, Lake Illawarra. 29-30, Nosed blades of borer type. E.33706, Murramarang, and E.38964, Lake Illawarra. 31, Coroid implement, plane-pusher type. E.39108, Bellambi. 32, Core with unused lip projecting from margin. E.49329, Bellambi. 33*a-b*, Piercers. E.39167, Bellambi, and E.33209, Murramarang. 34, Concave and nosed scraper. E.38773, Bellambi. 35, Straight-edge nose on blade. E.43090, Quibray. 36, Scraper, with triangular nose. E.33320, Murramarang. ⅔ natural size.

(*b*) *Side and end*: One from Murramarang is a thick blade, 5 cm. long, with step-chipping along the convex margin and end, and another is tortoise-shaped, with a median ridge, like a carinate scraper.

(*c*) *Double-side*: The ordinary variety trimmed on two opposite lateral margins is scarce. The commonest variety is made on a concavo-convex (laterally) or plunged flake; one margin is trimmed from the inner, and one from the outer, face, but some have a saw-like edge with tiny squills off both facets. Three from Tuross Heads are pointed (Fig. 21). Two are keeled, and one has three trimmed edges.

(*d*) *Double-side and end, or tongue-shaped*: Table V shows this variety to be uncommon, perhaps because of the predominance of asymmetrical flakes in the industry. Thus the 19 from Merimbula may be accounted for by the use at this site of comparatively tractable silicified sand and porphyry.

(*e*) *End*: A variety of end scrapers were employed. Some are blades, others broad and short flakes. The true "duckbill" variety is rare, although it is common as the "thumb-nail" scraper among those of microlithic size.

The straight edge may be on an oblique margin.

The convex-edged series vary from frail, thin flakes to stout, broad ones. One form has a central median ridge sloping upwards from the thin bulbar end to a high peak, from which the chipped face extends steeply to the trimmed edge (Fig. 27). Some are of the *elouera* form, but do not possess its other characteristics. There are two unusual examples from Lake Illawarra, both trimmed to an ogival shape; one (Fig. 26) is an irregular blade, 7·25 cm. long.

The butt-edged end scraper (Fig. 22) is a common implement. One variety has a thick butt, on which one or both edges are trimmed, and from it the implement tapers rapidly to a thin distal end. Some are normal flakes used on the butt edge, often with lateral margin trimming also. At Bellambi the majority are blades, and the minority squat flakes; three are trimmed from the inner face and nine from the outer face. One has a secondary butt at right angles to the striking platform, and all four edges have been used. One is of the *elouera* form, but has no other signs of use apart from the trimmed butt. Flakes with a faceted butt, on which there is additional retouch on the outer edge of the butt platform, are included in this group; this outer edge has been used particularly on thick-butted flakes. Malan (1942, p. 124) mentions this additional retouch on butt-end scrapers in the Modderpoort industry of South Africa. N. A and H. V. V. Noone (1940, p. 12) have pointed out that butt-end scrapers occur commonly between the late Acheulean and Bronze Age in Europe.

(*f*) *Concave*: The large number of concave-edged implements reveals this tool as one of the most characteristic of the industry, and illustrates clearly the relationship between the stone implement types and the material culture of the area. Concaves occur as 199 special tools, and occasionally on the *elouera* and *bondi* points, in the normal flake and blade group, on 80 coroids, 41 blocks, 10 slices, and commonly on the uniface pebble implements. Concaves are often multiple in number on separate implements. When it is considered that the main function of the stone implements in the south coast area was fashioning spears, clubs, parrying and broad shields, spear-throwers, boomerangs, ceremonial objects, and other wooden articles, many of which have rounded shafts, handles and apices, the reason for the importance of the concave edge is clear.

Concave scrapers are often used on other margins, and along the same margin as that on which there is a concave, as side scrapers and "nosed" gravers. The concave may be isolated on a margin, end, or corner of a flake; there may be several scattered along one margin or end, or one or more on several margins; it may be on the butt or distal end only, and a rare form is double-ended. A common variety has a concave on one or both margins, extending from the butt, so that it is somewhat tanged in appearance. The majority of the concaves are on blades, though some are on squat, irregular flakes, and usually on the thickest edge, thus utilizing the strongest part of the flake. Some are worked so deeply that the ends of the concave project as peaks, and many show pronounced step-chipping.

One (Fig. 28) from Lake Illawarra has a concave 3 cm. wide and 1 cm. deep, with a long thin arm forming one side of the tool. Another one has a concave on each lateral margin at the butt end and a trimmed end as well. One narrow blade from this site bears two small concaves on its distal end. There is a beautiful concave scraper in quartz from Murramarang.

(*g*) *"Nosed"*:[1] The table shows the "nose" to be a characteristic feature of the industry; it occurs on 69 flake and blade tools, 28 coroids, 37 blocks, 10 slices, and is common on uniface pebble implements. The "nose" is closely related to the broad-edged carinate scraper common among the blocks and coroids, and to the narrow-edged burinates. It is almost always situated between two concaves, each of which may be step-chipped as a result of use.

The "nose" occurs on stout flakes, often of irregular shape, and on blades, and may be on the lateral margin or end, or on both; a number of "noses" may project from a discoid or convex scraper edge.

An exceptional specimen (Fig. 29) from Murramarang is bat-shaped, with two long, slightly concave trimmed margins extending from the "nosed" distal end, and it might well be termed a borer; it is 6·5 cm. long. Another remarkable specimen (Fig. 30), from Lake Illawarra, is an irregular blade, 9·5 cm. long, with a trimmed "nose" at one end, a short concave on one lateral margin, a long concave on the other margin, and two concaves at the butt end. One variety has its distal end in the form of a rounded "nose" without concaves on each side. A long blade from Bellambi has two notched margins, and a broad trimmed "nose". The "nose" may be straight-edged (Fig. 35); on some it tends to be triangular (Fig. 36) in shape, but on the majority is rounded (Fig. 34). At Bellambi eight are rounded and five are triangular. The "noses" range up to 2·5 cm. wide across the base.

Most of the weapons of the south coast natives were decorated with incised geometrical designs, and it is probable that the "nosed" implement was employed in this work. Whether or not the "nose" on *elouera* industry implements is due to Tasmanoid influence, in which case it would be a survival in Australia, cannot be decided until other industries have been analysed to bring out its relative importance throughout the continent, but its presence in Australia is probably due to a functional need.

(*h*) *Utilized*: A miscellaneous series of flakes with signs of use of a minor nature on various margins. On some specimens, both scraping and cutting edges are present. One from Bellambi, 8 cm. long, has a concave scraping edge, 2·5 cm. wide, on one margin, one corner of its butt has been worn away by rubbing, and the other margin is a knife edge.

3. *Burinate.*—This type has not previously been described in Australia, but its differentiation is warranted. In the *elouera* industry material dealt with in this paper the burinate edge occurs on 40 flake and blade implements, 2 coroids, 1 block and 16 *elouera*, some of which are microlithic in size. A minority are perfect examples of simple burin types. It is not claimed, however, that a specialized burin technique was employed to make them, otherwise a larger number of true burins would be present, but as a group the specimens distinguished exhibit the principal character of the burin, which is a specially restricted, stoutly backed, but prominent, marginal working edge. In our series the burinate edge is formed by opposing one or more spalls against a prepared platform, or against a trimmed margin, and they have been classified accordingly (Noone, 1934). Thus it might be said that burinate implements were made by the aborigines of the south coast to do work similar to the true burin, which was engraving in this area, to judge by the decorative art designs in low relief, a purpose for which the "nosed" scraper was also employed.

It is important to note that the burinate edge is often combined with a scraper edge (convex, concave, or straight), or with a cutting edge on the one flake, and this

[1] It might be pointed out that the term "duckbill" has been used incorrectly for some time in Australia to denote the "nose"; the duckbill is a broad, convex end scraper, and the name should be limited to such tools.

feature has led to their not being readily recognized hitherto in Australia; many burinates lacking this secondary use have probably not been collected on various sites. The following are the types represented:

(*a*) *Spalled, with marginal platform*: The spalls have been removed across the transverse axis (Figs. 96–97) of the flake or blade on 14 specimens, and on 7 *elouera*, and down the longitudinal axis (Figs. 98–101) on 12 specimens, and on 7 *elouera*. The vertical is somewhat larger on the average than the transverse form. From one to four spalls (one being the commonest) have been removed to form the burinate edge, which shows signs of use on all examples. The platform surface, being a spall scar face, is usually slightly concave. The spalls extend the full length of the marginal face on the majority of specimens, but on some are fore-shortened and end in a projecting ledge, a common feature of burins. One specimen of the transverse variety has the spall scar face across the butt-platform of the flake. The burinate edge is straight on most of the examples, and slightly rounded or gouge-like on others. It is sometimes very narrow, almost pointed, but may be up to 1 cm. wide. The spall scar face is from 1 to 2·5 cm. long.

The end or *bec-de-flute* type is represented by one specimen from Tuross Heads, and two among the *elouera* from Port Kembla and Lake Illawarra.

(*b*) *Scaled*: An excellent series of thirteen specimens occurs among the *bondi* points, and their fashioning suggests a specialized technique. On each example a narrow spall has been removed from the point down the chord edge. This spall is approximately ·5 cm. long on most specimens, of which nine are less than 2·5 cm. long and microlithic in size (Fig. 103). The largest specimen (Fig. 102), from Bellambi, is 15 cm. long, with a trimmed oblique concave edge at the distal end, against which a spall 5·5 cm. long has been removed to form the burinate edge and face. The trimmed margin opposite the burinate or spall scar face varies from concave to convex.

(*c*) *Burinates on blocks and coroids*: The burinate edge occurs on three coroids and one block. One coroid (Fig. 99) from Quibray is a beaked type; it is 3 cm. long, with a straight edge ·75 cm. wide projecting from the body of the tool and bordered by two long slightly concave margins, the burinate edge being formed by the removal of two spalls, one long and one fore-shortened. The block from Murramarang is 5 cm. long, with a burinate edge, 1 cm. wide, formed by two shallow spalls; a flat natural surface, trimmed from the spall scar face, forms the platform, one edge of the latter being trimmed, and the opposite end of the implement bears a piercer-like "nose" on a trimmed margin. A core (Fig. 7) bears a skilfully prepared burinate edge in addition to its striking platform.

4. *Cutting*.—Table V shows that the cutting edge was as important in the *elouera* industry as the scraping edge. It occurs on 359 flake and blade implements, 186 out of 257 *elouera* from Bellambi (only), 275 *bondi* points, and on some of the slices and blocks. The knife edge develops into a saw-like edge as a result of use, but as the latter are mostly serrated, they have been classified in that group. The serrated edge (Fig. 20) is not as common as the knife edge, and both are usually on the longest margin of the flake. In the Bellambi series the knife edge is straight on 40 specimens, slightly concave on 7, and convex on 16. It is gapped on several specimens. There are 27 of *elouera* form which lack scraping use on the thick margin, and of these crust surface forms the thick margin on 15 specimens. Three are pointed flakes.

There is an unusual series of large serrated blades from Murramarang. One from Merimbula is curved at each end to form a long convex working edge. On some specimens there is a knife edge on one margin and a serrated edge on the opposite margin.

Functionally, the cutting edge in the *elouera* industry was probably used for body scarification, lacerating the gums in tooth avulsion, cutting animal flesh, skins, and fibres, skinning animals, and like purposes, for which shell knives and hafted shell chisels were also employed.

5. *Piercing* (Figs. 33*a–b*).—The peak or boring point is usually ridged on the outer face, flat on the inner face, and trimmed on one or both margins. It is distinct from the "nose" and the burinate edge. The flakes utilized are generally rectangular or pointed, and the piercer is often on one corner. They are uncommon in the industry, there being only 33 in the flake and blade group and 101 among the *bondi* points. The former is an irregular series, and the type is not conventionalized. There is a well defined series from Merimbula, on variously shaped flakes, one of which is an oblique blade, and one stout and strong. In the Bellambi series, five have the piercer or peak on a corner of the flake, and one has two piercers. The longest piercer in the series is ·75 cm.

6. *Flake fabricators* (*outils écaillés*).—This interesting group is represented by 205 specimens, and their function has been discussed under the heading of technique. Their essential character is that one or both facets of the working edge are battered and splintered. The edge is usually straight or slightly undulating on the longer examples, but gouge-like on the punch-type. Some are flimsy fragments, but the punch-type are stout and strong. In shape they are mostly parallelograms, some being chisel- or wedge-like, and others concavo-convex. They are, also, bifaces, in that most of them are trimmed on both surfaces. The punch-type is usually keeled, and may bear scraper or knife use on its lateral margins. Six varieties have been differentiated according to use, as follows: one margin (end or lateral), one margin and one end, two opposite lateral margins (Fig. 23), two lateral margins and one end, two lateral margins and two ends (four edges), and the punch-type used on both ends (Fig. 24). The punch-type occurs also on 14 *elouera*.

The table shows that the punch-type is the commonest variety, while those used on one margin and one end, and on four margins, are the most uncommon.

7. *Smoothed edges.*—At each of the eight sites, up to half-a-dozen flake and blade implements occur which have a smooth, polished edge on their longest margin. This polishing is not grinding or sand-blasting, but is caused by use. Some *elouera* bear this smoothing on their thin edge.

Size.—Apart from specimens of microlithic size (less than 2·5 cm.) normal flake and blade implements are between 2·5 and 7 cm. long at most of the sites from Bondi to Lake Illawarra, those from North Cronulla appearing to be slightly smaller on the average than the other sites. On the other hand, those from Tuross Heads, Murramarang, and Merimbula are up to 9 cm. long, and larger on the average than other sites. These differences in size are due mainly to the materials used, although at North Cronulla the microlithic influence is more pronounced.

Bondi Points.

The points have proved to be a most difficult but interesting group to analyse in what is the first attempt to classify and bring out their diverse characters. The name *bondi* (*bon-dai*) has been adopted for them, after the first locality from which they were figured in Australia by Etheridge and Whitelegge (1907), in preference to "Sydney" point used by Tindale (1941, p. 146), a name which has no real significance in connection with them. In all, 2,340 *bondi* points have been analysed, and we are confident that they include all characters of any importance.

Conformation.—Asymmetrical, with two types of blades, as follows: (1) triangular transverse section (Fig. 49) (isosceles to equilateral), with single-edged thin margin, double-edged thick margin, inner and outer cleavage faces, tapering in thickness from butt to point; (2) trapezoid or flattened in transverse section (Fig. 52), several ridges on outer face, inner cleavage face, two single-edged lateral margins, often thicker toward one than the other. The segments may be straight (Fig. 52), or curved (Fig. 53) at the distal end on both margins like a hook. The thin margin may be straight, incurved or convex. They vary from delicate slivers to thick, broad and stout blades. In Table VI the narrow blades are arbitrarily divided from the broad and rudder blades, and have not been defined by measurement. Points from narrow to medium in width predominate.

Figs. 37-103.—*Bondi points.* 37, Partly trimmed, faceted butt. E.34665, Tuross Heads. 38, Partly trimmed, plain butt. E.39040, Lake Illawarra. 39. Trimmed on distal end and butt. E.34486, Tuross Heads. 40, Oblique trimmed edge, trapeze shape. E.43859, Tuross Heads. 41, Oblique trimmed concave edge, broad. E.50284, Lake Illawarra. 42, Trimmed on distal end. E.36867, Quibray. 43, Trimmed on distal end and butt. E.39087, Seven-Mile Beach, Lake Illawarra. 44, Single-edge trimmed, straight but oblique butt. E.50008, Quibray. 45, Single-edge trimmed, faceted butt. E.50389, Lake Illawarra. 46, Double-edge trimmed. E.50012, Bellambi. 47, Rudder-shaped, trimmed concave distal end. E.50289, Lake Illawarra. 48, Broad, short,

Technique.—The impact spot is at the butt end on all specimens, the bulb of percussion usually occupying the greater part of the butt end of the inner face, and it is probable that a specialized technique was employed in knapping them from the cores.

Trimming.—The thick margin of the *bondi* points is abrupt-trimmed, the primary aim of the trimming being for shaping and not for use. The margin trimmed, when the outer face is uppermost, is on the left (Fig. 37) of the bulb of percussion on the majority of specimens. The partly finished group indicates that the trimming was started at the point end, there being very few specimens trimmed at the butt end only. On the trapezoidal-section points the trimming was taken (*a*) right along one edge only (Fig. 52), and (*b*) the butt was rounded off in addition (Fig. 51). On the triangular-section points the trimming was taken right along the thick margin (*a*) on one edge and extended across to the other edge near the point only, (*b*) on both edges (Figs. 49–50), and (*c*) the butt was rounded off on one or both edges (on a minority). Exceptions to this treatment are 69 specimens (Figs. 39, 43) with point end and butt trimmed, with a portion of plain margin between, and 166 specimens with partly (Fig. 37) or wholly trimmed margin and faceted butt, both of which constitute well-marked varieties.

The outline of the thick margin may or may not be altered by the trimming, which follows the natural straight or convex outline of the blade on a large number of specimens, but on others the outlines are shaped to a concave edge. Other characteristics are as follows:

(*a*) (Figs. 40–41, 47). The butt end is straight or convex, and the distal end is oblique and either straight or slightly incurved to form a rudder-shaped point. They occur in the partly finished, single-edge trimmed and double-edged trimmed points, and are a common variety.

(*b*) (Fig. 53). On the curved blades the oblique distal end is usually convex.

(*c*) (Figs. 60–62). There is a pronounced rounded corner, or hump, near the point, and the distal end is almost straight. Three from Quibray, with broken tips, have been trimmed to a rounded end, but these are rare at all sites.

(*d*) On two specimens from Quibray the trimming has been taken half-way along one edge, and then continued along the other edge of the thick margin.

(*e*) On a large number of specimens the workman has not been able to remove by trimming a hard knot on the margin, and has worked round it, leaving a rounded hump anywhere between the butt and the point, but commonly towards the distal end on stout examples.

Partly finished points.—It has not been found possible to separate the broad or oblique examples (Figs. 25, 38, 40–41), many of which could be termed oblique trimmed

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double-edge trimmed. E.48530, Tuross Heads. 49-51, Double-edge and butt trimmed. E.50009, E.31182, Boat Harbour, and E.33329, Murramarang. 52, Single-edge trimmed. E.11509, Boat Harbour. 53, Curved blade, single-edge trimmed, faceted butt. E.50008, Quibray. 54, Double-edge trimmed, with saw-like edge on thin margin. E.9080, Bondi. 55, Concave butt, rudder-shaped. E.50289, Lake Illawarra. 56, Tanged butt. E.41523, Redhead, Port Kembla. 57-58, Nosed butts. E.40036, Tuross Heads, and E.39006, Lake Illawarra. 59, Fluted, steep-faced triangular butt. E.35918, Murramarang. 60-62, Sharply-turned distal end, one with concave edge. E.50012, Bellambi, E.36832, Quibray, and E.39019, Lake Illawarra. 63, Trimmed on both margins at distal end. E.36797, Bellambi. 64-65, 67-69, Trimmed on both lateral margins. E.38650, E.39289, E.39264, North Cronulla, and E.41520, Lake Illawarra. 66, Trimmed on the three edges of two margins. E.36849, Lake Illawarra. 78, Right-angled butt. E.31182, North Cronulla. 85, Right-angled butt, distal end missing. E.9079, Bondi. *Microliths.* 70-72, 74, Crescents. Note the end trimmed off No. 72 at an oblique angle. E.36856, E.43896, Quibray, E. 34487, Tuross Heads, and E.49371, Bellambi. 73, 84, Equilateral. E.36851, E.43894, Quibray. 75-76, 83, 86, Trapezoid. E.36868, E.39276, Quibray. 77, Scalene. E.38924, Murramarang. 87, Oval, trimmed on both margins and end. E.39003, Lake Illawarra. 88-90, Thumb-nail scrapers. E.43891 (2), Quibray, and E.16378, Bondi. 91, Discoid, concave and nosed. E.16384, Bondi. 92, Thumb-nail, crowned end scraper. E.43095, Quibray. 93, Abrupt trimmed blade. E.16381, Bondi. 94, Crescent, piercer-like end. E.39316, Boat Harbour. 95, Large crescent. E.39076, Seven-Mile Beach, Lake Illawarra. *Burinates.* 96-97, Marginal-platform, transverse. E.32055, Boat Harbour, and E.38444, Bellambi. 98-101, Marginal-platform, vertical. E.43083, Quibray, E.38771, E.38847, E.43152, Bellambi. 102-3, Scaled. E.50075, Bellambi, and E.50041, Quibray. § natural size.

blades, from the narrow partly trimmed forms (Figs. 37, 39, 42) because they merge imperceptibly into one another without any definite line of demarcation. On some specimens, the trimmed portion of the margin is really the distal end at an angle, and they are true oblique blades. One broad specimen from Lake Illawarra is 3 cm. long and 2 cm. wide. It is possible that some of these blades represent a stage in the making of an angular microlith. The partly finished group is in a minority, the craftsmen being careful to blunt the whole margin, preferably along one edge, but also along two edges of the thick margin. On the trapezoid-section blades the upper ridge of the thick margin is centrally situated and is not convenient for trimming unless the lower edge is worked right back to it. Thus the aborigines spent a lot of time in fashioning these points, as the immense numbers of them on the kitchen-middens testify.

Standard type.—There are two varieties of the standard or ideal type, as follows: (*a*) completely trimmed on one edge and butt, the latter being rounded (Fig. 51), or with faceted butt, and (*b*) completely trimmed on two edges of one margin and butt, the latter being rounded (Figs. 49–50), or with faceted butt. It might be stated that the rounding of the butt was relatively unimportant, as shown by Table VI.

Trimmed on two margins.—There are two varieties, as follows:

(*a*) One edge of two margins. Ninety-five specimens are trimmed completely along one edge (usually the thicker margin), and either partly (isolated patches in the middle or towards one end) (Figs. 64, 68) or wholly (Figs. 65, 67) along the thinner margin, the latter being in the minority. Points of both triangular and trapezoidal section were used, the former being in the majority. A broad example (Fig. 69) from Port Kembla is 2·75 cm. long and 2 cm. wide, and one from Lake Illawarra is 2·75 cm. long and 2·25 cm. wide. One (Fig. 67) of these examples resembles the *pirri*.

(*b*) Three edges (Fig. 66). Eighteen specimens are trimmed on both edges of the thick margin, and either partly or wholly (the minority) on the thin margin.

Butt.—The butt is treated in a number of ways, some of which are normal and others unusual, as follows:

(*a*) Left plain, and varies from a thin edge to almost 1 cm. thick.

(*b*) Faceted (Fig. 37), a common feature on about one-third of the total. Several specimens with faceted butt have no marginal trimming.

(*c*) Rounded (Figs. 46, 49) by trimming on edge of inner face, or on two edges of the thick margin. This trimming may join the opposite thin margin in a sharp corner (Fig. 50), or extend slightly along this margin and so round off the whole of the butt (Fig. 51).

(*d*) Fluted by the removal of a number of spalls from the inner to the outer edge of the thick margin, the facet being at approximately 45° from the outer to the inner face. This type of butt is eminently suitable for graving use; it is actually a small "nose", and might have served this purpose on occasion, but, on the other hand, might be due to the edge of the outer face being inwards from the butt and not directly above the edge of the inner face (Figs. 58–59). One Port Kembla specimen (Fig. 56) has a tanged butt of this type, on which the trimming is taken round the concave outer margin of the tang, which is 3 mm. long.

(*e*) Concave edged (Fig. 55), there being only two specimens in the whole series, both narrow segments from Tuross Heads and Windang.

(*f*) Burinate, with several spallettes removed across the butt from the thick margin to the thin margin at an oblique angle. They are obtuse in shape, and the opposite to the scalene form of microlith. They occur at all sites, there being four from Murramarang.

Table VI shows that the plain butt is in the majority, and that the rounded and faceted butts are characteristic features of these points.

Thin margin use.—On 275 specimens are signs of knife use on this margin. Many have a well used saw-like edge (Fig. 54) with squills removed by use on both facets of the edge. One narrow segment from Port Kembla of the same type as the points, but not trimmed, has been used as a knife on this margin. Three examples from

Quibray have a concave trimmed edge at the butt end of the thin margin, but scraper use is very rare.

Piercer use.—One hundred and one specimens are trimmed on both margins round the point, probably for piercing use (Fig. 63). The trimming on the thin margin extends up to ·75 cm. from the point.

Scaled burins.—Thirteen examples occur among the *bondi* points, and are dealt with under burinates, p. 144.

Size.—Table VI shows shows that the points less than 3 cm. long predominate, those from 2 to 3 cm. being in the majority, followed by those up to 2 cm. long. Actually, as a whole, those less than 2·5 cm. form an absolute majority of microlithic points, an important point to bear in mind in considering the derivation of the *elouera* industry.

Materials.—Practically all of the materials of the industry are represented among the *bondi* points, with a preference for the finest grained. A large number are made of chert, jasper, silicified wood and sandstone, and some are made from attractively grained chalcedony.

Function.—It has been shown by the analysis that *bondi* points served a number of useful purposes, apparently secondary to their main function, whatever that was, and comprising cutting on the thin margin, very rarely scraping on the thin margin but more commonly on the thick margin, graving on the butt end where the butt is shaped for this purpose, and piercing with the point. It is suggested that the main function of the *bondi* point was similar to that of the bone *muduk* (McCarthy, 1940*c*), that is, as a spear barb and/or point, and that the use of the stone point was superseded by bone and wooden points and barbs of a dual nature. Thus they would be set in gum in a groove on the shaft, the butt end bound with sinew and also gummed. The large numbers of *bondi* points found indicate that they were not used for ritual purposes, and their use on spears is the only apparent one in connection with weapons. There is, however, no direct evidence to support this contention.

Microliths.

The microliths constitute a small but important group in the *elouera* industry. Six simple angular types are represented among the 142 specimens, and in addition there are 64 thumb-nail, 11 discoid, and 1 rectangular scrapers.

Crescents (Figs. 70–72, 74, 94–95).—These are the commonest type, and range from short and stout to long and slender or broad forms, some of which are miniatures of the *elouera*, but without any signs of use on the thin margin. One (Fig. 94) from Boat Harbour has a small concave on each margin so as to shape the pointed corner for piercing purposes, and on another one a single concave on the trimmed margin near the corner is probably for the same purpose. Those from Quibray are 1 to 3·25 cm. long, and from Bellambi 1·5 to 2 cm. long.

Trapezoids.—Two varieties may be distinguished, those with the shorter of the two parallel margins untrimmed (Figs. 76, 83), and those on which it is trimmed (Fig. 75), the latter being in the minority. In both groups are four main shapes, as follows: (*a*) elongate, including both symmetrical and asymmetrical forms, (*b*) medium, a symmetrical form on which the trimmed shorter margin is often the same length as the two oblique margins, (*c*) short, including both symmetrical and asymmetrical forms, broader than long, and (*d*) one trimmed margin at right angles to the longest margin. One from Tuross Heads has a sharp-pointed corner suitable for piercing. One from Bellambi is 3 cm. long and 2 cm. wide. In size they range from 1·5 to 2·75 cm.

Equilateral (Fig. 73).—Not very well represented. They vary from examples on which the two trimmed margins meet in a peak or sharp edge, to those on which it is rounded, the implement being hat-shaped in the latter case.

Isosceles (Figs. 79–80, 82).—They range from narrow to broad examples. The junction of the two trimmed margins often forms a peak or sharp edge.

Scalene (Fig. 77).—As with the two preceding types, the junction of the two trimmed margins forms a peak or sharp edge on the majority of the specimens;

otherwise it is rounded. Some of the specimens have almost a right angle formed at the junction of the shortest trimmed margin and long untrimmed margin.

Discoid (Figs. 87, 91).—Some are high-crowned, especially from North Cronulla and Bellambi. Two from Lake Illawarra, 1·5 and 1·75 cm. long, are trimmed round the whole of the margin except the narrow butt. They are not circular, but are oval in shape.

End or thumb-nail.—They vary from broad to elongate, and from flattened to high-crowned scrapers with either straight (Fig. 89) or convex (Figs. 88, 90) (on the majority) working edges.

Sizes.—An analysis of the lengths of the microliths is as follows: 0 to 2 cm., 91; 2 to 3 cm., 50; 3 to 4 cm., 1 (a crescent). Three are 1 cm. or less in length.

Towle's assertion (1935, pp. 119–20, 131) that crescents and other pygmy types found on the coastal sites are too scarce to be regarded as conventionalized tools, and are really variant forms, cannot be accepted. The angular microliths are exact reproductions of those found elsewhere in Australia, especially in Victoria, and in other parts of the world. Microliths are an integral part of the *elouera* industry.

Microlithic-size implements.—Apart from the angular microliths there are 409 implements less than 2·5 cm. long among the cores and normal flake and blade groups, and 1,880 out of 2,340 *bondi* points less than 3 cm. long. Thus the microlithic implements in the collection studied total 2,200 or approximately one-third of the collection.

Other Artefacts on South Coast Sites.

In addition to the knapped implements described in this paper, other artefacts on the sites include edge-ground axes (Thorpe, 1932; McCarthy, 1941*b*) and knives (Thorpe and McCarthy, 1933), axe-sharpening stones (McCarthy, 1941*b*), mortars (McCarthy, 1941*d*), fish-hook files (Thorpe, 1931*a*), percussion stones, bone awls and *muduk* (McCarthy, 1940*c*), shell implements, incised (Bramell, 1941) and magic stones (McCarthy, 1942). The edge-ground axes comprise uniface pebble, plain and trimmed pebble, trimmed coroid, and hammer-dressed types.

Affinities.

A stratified site in which all elements of the *elouera* industry occur has not yet been excavated, and rock-shelters which have been dug out have yielded little stratigraphical data.

In 1889 David and Etheridge secured several aboriginal skeletons from a rock-shelter, and a midden below it on the shore, at North Harbour, Port Jackson. The skeletons were covered with large stones, there were two white hand stencils in the rock-shelter, and one hundred and twenty yards away was a group of outline rock engravings of broad shields. The only artefacts found were two "siliceous knives", two edge-ground pebble axes, one of which was a split-pebble type, an edge-ground skinning-knife (?), and a fish-hook file. In 1889 also they described a skeleton from beneath a deposit of sand and pumice at Long Bay; associated with it were a flake and an edge-ground skinning knife. In 1896 Etheridge, David and Grimshaw described a submerged forest, with remains of the dugong, on an old land surface at Shea's Creek, Botany Bay; on this surface were found four ground-edge pebble axes. In 1899 Harper investigated several rock-shelters at Port Hacking, National Park, and from one at Little Jibbon obtained one adult and four children's skeletons, a bone awl, six perforated shell discs, and five stones for "breaking bones".

In 1934 Kennedy, from a rock-shelter at Pittwater which contained a deposit from one to three feet six inches deep, obtained the following specimens: 6 split-pebbles, 2 worked pebbles, 56 flake and blade implements, 1 *elouera*, 1 edge-ground knife, 1 core, 1 hammerstone, 1 rasp, and 2 pieces of red ochre; no *bondi* points or angular microliths were found. In 1934 McCarthy, from a rock-shelter near Emu Plains, listed the following specimens: 2 edge-ground pebble axes, 1 edge-ground knife, 1 uniface pebble

implement, 50 flake and blade implements, 4 *elouera*, 51 *bondi* points, 4 cores, 1 hammer-stone, 2 quartz crystals, and a fragment of a human skull, with some teeth. No angular microliths were present. In 1931 members of the Anthropological Society of New South Wales investigated a large rock-shelter at Lake Burrill, from which Thorpe (1931–1932) stated that more than 450 artefacts were obtained, but gave few details of their nature; the collection from this site, now in the Australian Museum, is as follows: 16 cores, 3 core implements (1 burinate), 1 biface discoid coroid, 2 crown blocks (1 discoid, 1 concave), 9 carinate blocks (1 nosed), 2 slices, 3 uniface pebble implements (2 end (cores?), 1 lateral), 17 *elouera*, 98 scrapers (31 side, 7 double-side, 7 end, 9 butt-end, 2 double-side and end, 26 concave, 11 concave and nosed, 5 utilized), 28 knives, 7 serrated, 6 burinate, 4 piercers, 18 flake fabricators, 8 percussion stones (3 coroid, 4 pebble, 1 anvil), a total of 222 implements, the remainder being unused flakes. The site was not stratified, and no angular microliths or *bondi* points were present. Generally speaking, the implements from this rock-shelter closely resemble those from Murramarang, about ten miles to the south.

Small series of specimens from test-trenches in rock-shelters on the Lane Cove and George's Rivers, in Howe's Valley, and in the Bulga district, some of which contain hand stencils, include various normal flake and blade implements, some microlithic end-scrapers, *elouera*, *bondi* points, a fish-hook file, bone implements, 1 flake fabricator, but no pebble implements. It is clear, therefore, that the *elouera* industry occurs both in rock-shelters and on open sites, which may or may not be shell-middens.

There remains to be considered the question of whether the *elouera* industry is a locally developed one, or has been built up by intermittent infusions of culture. The latter process has, it appears, been the case, and in this connection the microlithic, uniface pebble, edge-ground and hammer-dressing techniques, fish-hooks and files, and the bone *muduk* appear to be important extraneous items. The uniface pebble implements are of the same nature and varieties as those of the *kartan* culture of Kangaroo Island (Tindale and Maegraith, 1931; Tindale, 1937, 1941) and of Yamba and Crescent Head (McCarthy, 1941*a*), where they occur as a distinct series, now regarded as an extension of the Hoabinhien I culture to Australia (McCarthy, 1938, 1940*a*).

Geometrical microliths are widely distributed in Australia and, taken in conjunction with the large number of flake and blade implements of microlithic size, appear to constitute a distinct culture, of which the *elouera* industry may well be a variant. The possibility of the microlithic culture being an independent development in Australia must be considered, and it is not known whether it is historically related to Asiatic cultures of the same nature, especially in India. The edge-ground technique in south-eastern Asia and Malaya first appears in the Hoabinhien II culture during the "mesolithic" period, and the hammer-dressing technique during early neolithic times (McCarthy, 1938, 1940*a*), and both techniques appear to have spread by means of the migrations and contacts of the early groups of people who invaded the Oceanic region.

Tindale (1941, p. 147) linked the *elouera* industry with the *pirrian* of the Devon Downs site on the Lower Murray River, and stated that the *pirrian* "is dominated by the *pirri* or leaf-shaped point, but the small so-called 'Sydney' point, which has a triangular section and the back worked so that one end of the blade forms a point, also occurs, as well as a rather typical *elouera*". The other elements of the *elouera* industry do not occur in the *pirrian*.

There is evidence to believe, the evidence being limited to distributional data at present, that the bone *muduk* (McCarthy, 1940*c*), and the making of fish-hooks (McCarthy, 1940*b*, p. 269) spread down the east coast from Cape York, and both are probably New Guinea influences.

Patination occurs on odd artefacts in the *elouera* industry of the coastal kitchen-middens, but not generally in any series of the one technique or type.

Horne (1921) has described the stone implements of south-eastern Victoria, where most of the artefacts in the *elouera* industry occur, the most notable deficiency being the *elouera* itself, although it might be present in this area because it had not been differentiated as a conventionalized type when his paper was written. Kenyon (1927),

too, has shown that many elements of the *elouera* industry occur on Victorian sites, but more detailed analyses are required before the relationships can be specified more precisely. Mr. H. V. V. Noone has informed me that he has identified typical *elouera* in the Queensland Museum collection from Bundaberg and Stradbroke Island, in the South Australian Museum from south-eastern South Australia, and in the Western Australian Museum mounted as a *tula*. The Australian Museum possesses an *elouera* from Hook Island, Whitsunday Group, Great Barrier Reef, and odd specimens from western New South Wales.

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A NOTE ON THE MICRO-TEXTURE OF THE ARLTUNGA METEORITE.

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(Figure 1.)

The Arltunga meteoritic iron is of interest because its micro-texture, as might be expected from its composition (10·22% Ni), illustrates a stage in the development of the Widmanstätten structure, which is intermediate between the incipient stage, as shown in the Tawallah Valley iron (16·90% Ni) (Hodge-Smith and Edwards, 1941), and the fully developed structure of the octahedrites proper (6%–8% Ni).

Mawson (1934), who described the Arltunga iron, and classed it as an ataxite or micro-octahedrite, gained the impression at the magnification at which he worked (up to 500 diameters) that the fine octahedral structure of the iron arose from the alignment in octahedral fashion of "taenite rods . . . embedded in a directionless kamacite nickel-iron alloy low in nickel content" (1934, p. 2, and description of Plate i, Fig. 4). Such a structure is inconsistent with the explanation of the origin of the Widmanstätten structure put forward to explain the micro-texture of the Tawallah Valley iron (Hodge-Smith and Edwards, 1941, p. 6), which called for the development of ex-solution bodies of α-nickel-iron (kamacite) in the octahedral directions of the original γ-nickel-iron (taenite). In meteorites with a lower Ni content than the Tawallah Valley iron, the transformation to α-iron is more complete, and the ex-solution bodies develop into parallel plates, the residual high nickel γ-iron being trapped as thin lamellae between the plates of α-iron. The structure of the Arltunga iron as interpreted by Mawson would be the reverse of this.

A mineragraphic examination was made, therefore, of the small piece of the Arltunga iron lodged in the Australian Museum. A polished section was prepared on a Vanderbilt polishing machine, and examined at magnifications up to 1,000 diameters. The results indicated that Mawson was mistaken in his identification of the rods and blebs of the structure as γ-iron (taenite), and that the octahedral structure is due to the alignment in octahedral fashion of small plates of α-iron (kamacite) about 1/1,000 to 1/2,000 inch thick, interleaved with still smaller plates of γ-iron (taenite), which have a maximum width of 1/20,000 inch. These latter plates are only visible at high magnification, and with the high degree of polish obtainable with the polishing machine. Fig. 1 shows a field of view magnified by 800 diameters, in which the α-iron (kamacite) has a roughened surface, resulting from etching with 2% HNO_3 in alcohol, while the interleaved γ-iron (taenite) has a smooth, unetched surface.

The etching behaviour of these two components when treated with standard mineragraphic etching reagents conforms with the behaviour of undoubted α-iron (kamacite) and γ-iron (taenite) respectively (Edwards and Baker, 1942, pp. 10–11). The broader α-iron bands are immediately etched by HNO_3, but without effervescence; HCl fumes tarnish them brownish, but the action is not consistent; KOH and KCN are negative; FeCl instantly turns the iron brown to black, bringing up the grain boundaries; $HgCl_2$ darkens the surface immediately.

The thinner γ-iron bands remain unattacked by any of these reagents, with the doubtful exception of HCl, which sometimes tarnished them.

This revised interpretation of the micro-structure is consistent with that shown by other meteoritic irons, and with the theory previously referred to; and it is suggested that this iron should be classed, like the Tawallah Valley iron, as an eotaxite, or, if it is regarded as having a too well-developed octahedral structure for this, as a micro-octahedrite.

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Fig. 1.—Micro-octahedrite structure of the Arltunga meteorite, magnified 800 diameters. Surface etched with 2% HNO_3 in alcohol, and showing etched plates of α-iron (kamacite) with a roughened surface, with thin interleaved lamellae of unetched γ-iron (taenite). Small blebs of unetched phosphide (schreibersite) occur in the kamacite plates.

A PERMIAN AMMONOID FROM NEW SOUTH WALES AND THE CORRELATION OF THE UPPER MARINE SERIES.

By Curt Teichert and H. O. Fletcher.

(Plate xi, and Figures 1–3.)

Abstract.—References to alleged occurrences of ammonoids in the Permian of New South Wales are numerous. With the exception of the one specimen described in this paper they all seem to refer to bellerophontids identical with or related to *Warthia micromphala* (Morris). An abbreviated historical review of that species is, therefore, included. The only indubitable ammonoid from the Permian of New South Wales was found in the Branxton stage of the Upper Marine series of the Hunter River Valley. The specimen represents a new species which is described as *Adrianites* (*Neocrimites*) *meridionalis*. The evolutionary stage reached by that species indicates an Artinskian age for the Branxton beds.

A state of uncertainty has long existed regarding the occurrence of ammonoids in the Permian of New South Wales. A certain species, originally described as *Bellerophon micromphalus* by Morris in 1845, has subsequently been referred by different workers to such genera as *Goniatites*, *Agathiceras*, *Warthia*, *Prolecanites*, *Paralegoceras* and others, and it seems remarkable that no up-to-date description of any specimens to which any of these names has been attached should be available. The purpose of the present paper is to describe the only true ammonoid to which this specific name has ever been applied, and which, incidentally, is the only ammonoid ever secured from the Permian sequence in New South Wales. In order to clear the ground it will be advisable to go into the history of "*Bellerophon micromphalus*" and to demonstrate the many changes in the conception of that species.

Historical Notes on "Bellerophon micromphalus".

"*Bellerophon micromphalus*" was originally described by Morris (1845, p. 288, pl. 18, fig. 7) from the Upper Marine series of the Permian in the Illawarra District, New South Wales, but the specimen figured by its author is quite unlike what was later to be considered as a typical shell of that species.

In 1847, McCoy (p. 308) recorded *Bellerophon micromphalus* from Wollongong and added that it was rare in the Muree sandstone of the Hunter River Valley. In the same year, Dana described *Bellerophon undulatus* from Harper's Hill and *B. strictus* from Illawarra. Two years later, Dana (1849, pp. 707–8) recorded and figured the same two species in addition to *Bellerophon micromphalus*, but his figure of the last-mentioned species is different from the figure published by Morris.

de Koninck (1877, p. 201) placed *B. undulatus* Dana in the synonymy of *B. micromphalus* and, although he had seen no traces of septa, transferred the species to the genus *Goniatites* because of its external appearance. He apparently overlooked the fact that as early as 1850 Römer had already described a species from the Upper Devonian of Germany which he had named "*Goniatites micromphalus*". de Koninck's description of the species was repeated unchanged in the English edition of his work published in 1898.

In the meantime, Etheridge (1878, p. 89) had listed "*Goniatites micromphalus*" as doubtfully related to *Aganides* Montfort, and (1880, p. 304) recorded the species from the Bowen River coalfield in Queensland. This reference was repeated by Etheridge in

1892 (p. 294). However, as early as 1880, Waagen had studied bellerophontids from the Productus limestone of the Salt Range in India and instituted a new genus *Warthia* for shells which showed no trace of a slit-band and were strongly involute and compressed, and (1880, p. 160) he stated his opinion that the Australian species *Bellerophon undulatus*, *B. strictus* and *B. micromphalus* undoubtedly belonged to this genus.

Foord (1890) recorded "*Goniatites micromphalus*" from the Kimberley district of Western Australia, but stated that his specimens were poor and showed no trace of septa.

Etheridge (1894) described and figured three specimens from the Upper Marine series which he called "*Goniatites* (*Prolecanites?*) *micromphalus*". Among his figures is one of a portion of a suture, but it is not stated from which of the specimens it was drawn. Etheridge discussed the possibility that the species might either belong to *Sandbergeroceras* Hyatt or to *Prolecanites* Mojsisovics. In the same year and having had access to Etheridge's paper, Foord and Crick noted the resemblance of Etheridge's specimens, particularly the suture, to *Agathiceras uralicum* Karpinsky from the Artinsk beds of Russia, and they therefore referred the species with reservation to the genus *Agathiceras*.

Frech, on the other hand, stated two years later (1896, p. 501) that the general form and spiral ornaments of this species agree with *Gastrioceras*, while its lobes agree with those of *Prolecanites* or *Pronorites*. At that time, of course, a complete suture was not known, as Etheridge had only figured a few of the lobes and saddles, and Frech thought that when this was known the species might possibly have to be referred to a new genus.

In 1904 Chapman recorded "*Goniatites micromphalus*" from the Irwin River district, Western Australia, without offering further comments, but in general the species was more or less confidently referred to *Agathiceras* as proposed by Foord and Crick. It is thus listed in many papers dealing with the Permian of Australia—as *e.g.* in David's monograph of the Hunter River coal fields, to mention only one of the most notable contributions—right up to 1924, when Chapman listed "*Agathiceras micromphalum*" from the "Carbo-Permian" of Port Keats in the Northern Territory.

Of foreign references to the Australian species during this period might be mentioned Haug, who (1898, p. 33) included it in the list of then known species of *Agathiceras*, and Haniel, who in his description of Permian cephalopods from Timor (1915) compared "*Goniatites* (*Agathiceras?*) *micromphalum*" with his own *Agathiceras sundaicum* and *A. cancellatum*.

Girty (1908, p. 482) favoured the bellerophontid affinities of the species when he stated that in all probability it would prove to be a *Warthia*. In Australia its true affinities were first recognized by Whitehouse in 1926, who listed "*Bellerophon* (*Warthia*) *micromphalus*" among Permian species from eastern Australia. No further observations were, however, communicated, and in 1928 "*Agathiceras micromphalum*" was again mentioned from the Permian of Australia in a comprehensive review published by Schuchert.

Some further progress was made in the following year, 1929, when Thomas reported that he and Dr. Spath had examined specimens of alleged *Agathiceras micromphalum* from Australia, but found that they could equally well be bellerophontids. In the same year Reid (1929, p. 80) published a communication received from Dr. Whitehouse to the effect that "two similarly coiled species, a common gastropod and a rare cephalopod, have been referred to this one species by earlier writers", in particular by Etheridge in 1894. This is the first suggestion that the specimens which had been given the specific name *micromphalus* might not necessarily all be conspecific, and that the name had been applied to gastropods as well as to a cephalopod.

In the following year Reed (1930, p. 43) described some fossils from the Permian of Brazil, which closely resembled Morris's species, as "*Bellerophon?* cf. *micromphalus*", stating that the true position of the species must remain an open question. Two years later, however, he (1932, p. 69) unreservedly identified "*Warthia micromphala* (Morris)" from the Agglomeratic Shales of Kashmir; he comments on the remarkable

fact that Etheridge was the only author who had ever observed any traces of septa in any specimens that had ever been referred to that species and that nobody else had been able to confirm such observations.

David and Süssmilch (1931, p. 500) helped to solve some of the mystery surrounding the species by stating that "the only specimen of an *Agathiceras* found in Australia and showing a suture, and referred by Etheridge to *Agathiceras micromphalum*, was obtained from a shaft sunk in the Upper Marine Series, at a horizon a few hundred feet above the top of the Greta Coal Measures". Furthermore, the authors state that the Ravensfield sandstone is particularly rich in a fossil classed as *Agathiceras micromphalum*, but now considered to be a *Bellerophon*. On the same page Whitehouse is quoted as questioning the affinities of the ammonoid with *Agathiceras*; he considered it to be nearer to *Paralegoceras*.

There have been no more recent contributions to the solution of the problem. Miller and Furnish (1940, p. 119) included Australia in the list of countries from which species of *Agathiceras* were known, and Teichert (1942, p. 223) stated that the only ammonoid ever reported from eastern Australia was an alleged *Paragastrioceras* from Queensland, implying that all references to "*Agathiceras*" or other ammonoid genera in eastern Australia were erroneous.

These historical notes, which are, it is hoped, complete in essentials, show that the specific name "*micromphalus*" has by different authors been more or less loosely attached to the following generic names of ammonoids: *Goniatites*, *Aganides*, *Sandbergeroceras*, *Prolecanites*, *Agathiceras*, *Gastrioceras*, *Pronorites*, and *Paralegoceras*. Moreover, it shows that the only pertinent observations that have ever been made are those published by Etheridge in 1894; that most authors who speculated on the affinities of the species relied on Etheridge's not very comprehensive descriptions and had never seen his original specimens; and that all other authors who had ever studied specimens of "*Bellerophon micromphalus*" had failed to find any traces of septa.[1]

Since Whitehouse had indicated that Etheridge had referred a gastropod as well as a cephalopod to the same species, and since David and Sussmilch had stated that only one single specimen showing suture lines had so far been found, a restudy of Etheridge's original specimens was apparently needed.

Occurrence of Adrianites and its Stratigraphical Significance.

An examination of the specimens on which Etheridge based his description of "*Goniatites* (*Prolecanites?*) *micromphalus*, Morris, sp." in 1894 revealed the fact that Etheridge had before him two specimens. One specimen served as original for figs. 9, 12 and 14 on pl. vii of his paper; the second specimen is represented by figs. 10, 11 and 13. The second specimen is a bellerophontid and belongs without doubt to the genus *Warthia*, although it may not be conspecific with *Bellerophon micromphalus* of Morris. It will not be further considered in this paper.

The first specimen is an ammonoid and must be the one referred to by David and Sussmilch as having been obtained from a shaft sunk in the Upper Marine series, at a horizon a few hundred feet above the Greta Coal Measures; therefore, this specimen comes from the Branxton beds of the Upper Marine series of the Hunter River Valley.

This ammonoid cannot be referred to any of the genera with which it has ever been compared; it clearly belongs to the family Adrianitidae. It might still fall within the range of the genus *Adrianites*, taken in its broader sense, although some Russian workers would undoubtedly include it in a group of early species to which they have recently applied the generic name *Neocrimites*. The species will be described below as *Adrianites* (*Neocrimites*) *meridionalis*, n. sp.[2]

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[1] Whether or not all aseptate specimens are in fact conspecific with Morris's holotype of *Bellerophon micromphalus* is a question that cannot be discussed in this place.

[2] While the genus *Agathiceras* must for the present be removed from the list of Permian fossils in New South Wales, it may be noted that a representative of that genus has recently been found in Western Australia (Teichert, *Jour. of Paleontology*, in press).

The stage of development reached by this species indicates fairly clearly that the beds from which it was obtained must be either of Artinskian age or only slightly younger, of an age corresponding to that of the Sosio beds of Sicily or of the Basleo beds of Timor. In other words these beds must be correlated with some part of the *Perrinites* zone or of the *Waagenoceras* zone of the Permian (= Leonard + Word formations of Texas, = Artinskian + Kungurian of Russia). In the terminology of American authors they would be definitely of "Middle Permian" age, although earlier writers would have classified them as Lower Permian, as also do most contemporaneous Russian geologists.

As will be explained below, certain features of the suture of *Adrianites meridionalis* suggest affinities to earlier rather than to later species within this time interval and the evidence of the ammonoid is thus distinctly more in favour of an Artinskian age of the Branxton stage. Conclusions reached earlier in a more indirect way by Teichert (1939, 1941) have thus been essentially substantiated.

In view of the great importance which is attached to this species for the correlation of the Upper Marine series, a somewhat more detailed account of the development and distribution of the family Adrianitidae is here included.

The Family Adrianitidae.

It is only in very recent years that the structure of the genus *Adrianites* and its various sections has been properly understood, particularly since Schindewolf, in 1931, established definite criteria for the distinction between *Adrianites* and *Agathiceras*, two genera which are externally very similar, but which Schindewolf suggested should be placed in different families on account of differences in the position of their siphuncles in early ontogenetical stages. Schindewolf's conclusions were not accepted by Plummer and Scott in 1937; however, they were strongly supported by studies of the ontogenetical development of the suture of the two genera which were published independently in the same year (1939) by Ruzhencev and by Miller and Furnish. Substantial additions to the knowledge of the Adrianitidae have also been made by Toumansky in papers published in 1937, and in additional papers by Ruzhencev (1940) and by Miller and Furnish (1940).

When Schindewolf established the family Adrianitidae, he included in it the genera *Adrianites* Gemmellaro, *Doryceras* Gemmellaro, *Pseudagathiceras* Schindewolf, and *Epadrianites* Schindewolf. Toumansky, in 1937, added *Hoffmannia* Gemmellaro and the new genera *Crimites*, *Sizilites*, and *Palermites* to the list. Miller and Furnish (1939, 1940) were critical of the validity of most of these genera. They concluded that "there is considerable variation within the genus *Adrianites*" and that "little if anything is to be gained by subdividing the genus".

In 1940, however, Ruzhencev added a new genus, *Neocrimites*, to the family and at the same time he also discussed the broader relationships of the group. It seems to us that Ruzhencev has established some definite evolutionary trends within the family Adrianitidae and his results lead to satisfactory correlations as far as the Australian species is concerned. The study of Russian faunas led Ruzhencev to the establishment of a phylogenetical series which is documented by the following genera: *Emilites—Crimites—Neocrimites—Adrianites*. He expressed doubt as to the proper taxonomic position of the other genera that have been referred to the same family, viz. *Epadrianites*, *Pseudagathiceras*, *Doryceras*, *Sizilites*, and *Palermites*. In this place there is no need to enter into a discussion of any of these genera, because the Australian species described in this paper is unrelated to all of them.

Ruzhencev's phylogenetical series of the Adrianitidae, s. str., however, deserves closer examination from the Australian point of view. It begins with *Emilites* in the Upper Carboniferous of North America and the Urals. The external suture of this genus has two fully developed pairs of lateral lobes, in addition to numerous indistinct umbilical lobes, and a fully developed ventral lobe subdivided by a ventral saddle. As Miller and Furnish, and Ruzhencev have shown, new lobes during the ontogenetical

development of *Adrianites* originate in the umbilical region and migrate towards the external as well as the internal side. In conformity with ontogenetical observation is the phylogenetical evidence; in the Sakmarian there appear species which have four pairs of external lobes. Such species are almost indistinguishable from species of *Agathiceras* and have in the past often been confused with them. In 1937 Toumansky established the genus *Crimites* for species of the Adrianitidae which had reached this or an only slightly more advanced stage. The genotype, *Crimites pamiricus*, possesses four external lobes (Fig. 1), three on the flanks and one on the umbilical wall, but

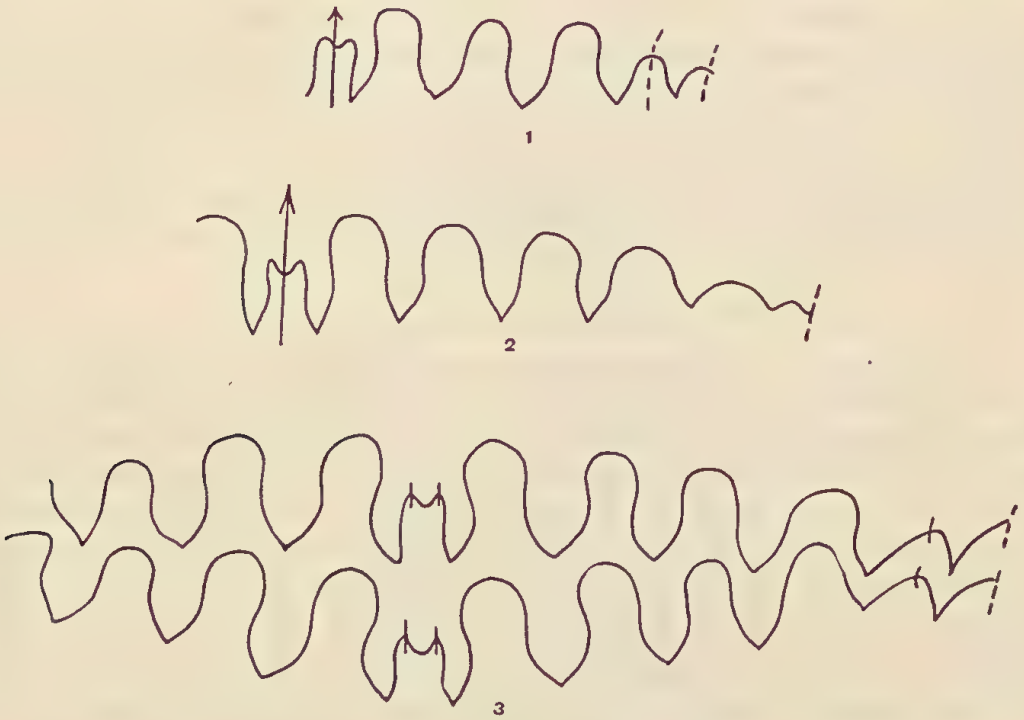

Fig. 1.—External suture of *Crimites pamiricus* Toumansky. (Adapted from Toumansky, 1937*a*, p. 377.) ×1·7.

Fig. 2.—External suture of *Neocrimites fredericksi* (Emilianzev). (Adapted from Ruzhencev, 1940, p. 838.) ×1·7.

Fig. 3.—External sutures of *Adrianites* (*Neocrimites*) *meridionalis*, n. sp. Holotype. ×4.

Toumansky included in the genus a number of species from Timor and Sicily which have four lateral lobes in the external suture. This generic name was later restricted by Ruzhencev (1940) to species resembling the genotype in the number of lobes; for forms with an additional lateral lobe he introduced the generic name *Neocrimites*, with *Adrianites fredericksi* Emilianzev as genotype (Fig. 2). Whereas species of the *Crimites* stage as restricted by Ruzhencev have apparently not been found outside Russia, the *Neocrimites* stage is also found outside Russia in Timor, Sicily and in Texas. According to Maximova and Ruzhencev (1940), "*Crimites*" appears in the Sakmarian and ranges upward into the Artinskian, whereas "*Neocrimites*" does not make its appearance before the Artinskian. It is rather typical of Artinskian time, but apparently survived until later, if the occurrence in the Sosio beds of Sicily is genuine. However, species with five external lateral lobes also appeared in the Artinskian and it seems that four- and five-lobed species coexisted throughout Artinskian and the following Sosio time, but that on the whole they were more characteristic of the earlier period. The Sosio beds and their equivalents elsewhere characteristically contain species with more than five external lobes. This indeed is the group of species for which the genus *Adrianites* was originally established by Gemmellaro and to which also belong such extra-Sicilian species as *Adrianites adamsi* Miller and Furnish from the Word formation of Texas and *Adrianites dunbari* from the *Timorites* zone of Coahuila in Mexico. The genus was later made to include species with a more primitive suture, but already Schindewolf, in his first treatment of the Adrianitidae

(1931, p. 200), suspected that such species might have to be separated as an independent generic group. Although on the other hand Miller and Furnish's warning that the genus *Adrianites* includes many variable elements which apparently are connected by transition stages should not go unheeded, it seems to be advisable for the present to preserve as subgenera some of the names that have been proposed for distinct phylogenetical stages. *Emilites* will undoubtedly constitute a distinct genus from which *Adrianites* arose in three distinct stages which may be known as three subgenera: *Adrianites* (*Crimites*)—*Adrianites* (*Neocrimites*)—*Adrianites* (*Adrianites*).

The suture of *Adrianites meridionalis* from the Upper Marine series of New South Wales corresponds most closely to the *Neocrimites* stage of the adrianitid suture and from the uncomplicated nature of the umbilical portion of the suture of the Australian species it seems possible to conclude that it is contemporaneous with earlier rather than with later species of this stage. The evidence of the species, while definitely indicating a "Middle Permian" age of the strata, is perhaps slightly more in favour of an "early Middle Permian", Artinskian, than of a Kungurian age.

Description of the Species.

Genus Adrianites Gemmellaro.

Subgenus Neocrimites Ruzhencev.

Adrianites (Neocrimites) meridionalis, n. sp.

(Plate xi, figs. 1–4.)

Goniatites (*Prolecanites?*) *micromphalus*, Morris, R. Etheridge, Jr., Rec. Geol. Surv. N.S.W., iv, 1894, pp. 36–37, pl. vii, figs. 9, 12, 14 (not 10, 11, 13).

The holotype and only known specimen seems to be septate throughout so that no portion of the living chamber is preserved. The shell is involute, moderately compressed, subdiscoidal, with evenly rounded venter and only slightly converging sides. The following measurements have been taken from the specimen:

Greatest diameter	31·1 mm.
Greatest width	19·7 mm.
Greatest height of last whorl	15·5 mm.
Height of last whorl above venter of preceding whorl	about 8·0 mm.
Width of umbilicus	3·6 mm.

The surface of the test which is preserved in some places bears transverse lirae. Near the adoral end of the last whorl there are about 15 of these lirae in a distance of 5 mm. The lirae are slightly sinuous and form two shallow lateral lobes and saddles and an equally shallow ventral lobe. They are crossed by still finer longitudinal lirae so that the surface on close examination appears to be reticulate. The spacing of the longitudinal lirae is about the same as that of the transverse ones.

Only the external portion of the sutures has been studied (Fig. 3). This consists of the ventral lobe which is subdivided by the ventral saddle, four pairs of lateral lobes, one pair of umbilical lobes, and four pairs of lateral saddles, in addition to one pair of umbilical saddles. The saddle subdividing the ventral lobe is approximately one-half as high as the adjacent first lateral saddle. The two prongs of the ventral lobe are narrow and slightly curved ventrad. Each prong is only about half as wide as the adjacent first lateral lobe. All the lateral lobes are obtusely pointed. They decrease gradually in size from the ventro-lateral sides to the umbilicus. The first two lateral lobes are somewhat tongue-shaped and slightly constricted in the adoral part, the third lateral lobe is unconstricted, and the fourth is wide open adorally. All the saddles are rather narrowly rounded. The general course of the sutures is directly transverse to the long axis of the conch.

Occurrence: Maitland Colliery Company's shaft, near Farley, New South Wales. Collected at a horizon a few hundred feet above the Greta Coal Seam.

Horizon: Branxton Stage of the Upper Marine Series.

Holotype: F 35732, Australian Museum, Sydney.

Remarks: *Adrianites meridionalis* is remarkable on account of its compressed whorl section. The only comparable species in this respect is *Adrianites discoidalis* (Haniel) from the Basleo beds of Timor (Haniel, 1915, pl. 5, figs. 2*a–c*), but that species has a more advanced suture with five external lateral lobes and was included in *Adrianites* s. str. by Ruzhencev (1940, p. 839). The only other species with which *Adrianites meridionalis* can be compared is *Adrianites newelli* Miller and Furnish from the Leonard formation (Artinskian) of the Glass Mountains, Texas (Miller and Furnish, 1940, p. 117). This species has an external suture which closely resembles that of the Australian species, and the degree of involution is also very similar in both forms. The Texas species is, however, somewhat broader and the longitudinal ornamentation of its conch is much more prominent.

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EXPLANATION OF PLATE XI.

Adrianites (*Neocrimites*) *meridionalis* Teichert and Fletcher, n. sp.

Fig. 1.—Lateral view, × 2.

Figs. 2 and 3.—Two ventral aspects, × 2.

Fig. 4.—Portion of surface of the conch enlarged, × 3.

TRIMMED PEBBLE IMPLEMENTS OF *KARTAN* TYPE FROM ANCIENT KITCHEN-MIDDENS AT CLYBUCCA, NEW SOUTH WALES.

By Frederick D. McCarthy,
The Australian Museum.

(Plate xii, and Figure 1.)

This preliminary note describes a small series of pebble implements from ancient kitchen-middens in the Kempsey district on the north coast of New South Wales. Mr. A. H. Voisey (1934, p. 94) described the site as follows:

> A heavy deposit of shells follows the somewhat irregular line of the old coast almost continuously from Grassy Head to Collombatti, keeping at about the same general height of ten feet above high-tide level. *Ostrea cucullata* and *Arca trapezia* are the most common shells. An occasional gastropod is found, while human bones and pieces of flint have been reported from Collombatti. Most of the *Arca* shells have been broken at the posterior margin, a circumstance indicating that the deposit represents not a raised beach, but an aboriginal kitchen-midden . . . it appears probable for the Kempsey area that the water in which the molluscs lived lapped the old cliffs during the human period, or, in other words, that the emergence which drove the sea eastwards occurred after the advent of the aborigines.

During a reconnaissance to this locality in May 1940, I was able to examine part of these middens, which appear at present as grass-covered mounds extending for some miles along the bank of Clybucca Creek. They are composed of a closely packed mass of the shells of the most abundant gregarious molluscs of mud-flat habitat, the Drift Oyster (*Ostrea cucullata*), Cockle (*Arca trapezia*), Sydney Whelks (*Pyrazus herculeus* and *australis*), and the Sea Snail (*Polinices strangei*), the two former predominating. Mr. T. Iredale, Conchologist at the Australian Museum, has informed me that these molluscs develop in comparatively still water on tidal flats, a condition which existed at the time they were collected by the aborigines (Voisey, 1934, p. 101). The thickness of the deposits is considerable; one pit, dug by lime-burners who have carted away large quantities of the shells, has a face seven feet deep which did not expose the surface upon which the middens lie. Reddish coloured firestones, suitable for crushing into pigment, are common among the shells.

The following implements were collected in the lime-burners' pits, and in and on the surface of the middens:

Cores.—Five specimens. E.48688 is a globular quartzite pebble, 8·5 cm. in greatest diameter and 21 oz. in weight, knapped all over its surface. E.48689–90 are irregular quartzite cores, 7·5 and 10 cm. long, 6 and 19 oz. in weight. E.48694 is oval and high-crowned, 10 × 8 × 6 cm. and 28oz., with a knapped margin along one side and end which may have been used for chopping; it is a coarse-grained, hardened sedimentary rock, not very suitable for flake implements. E.48693 is a flat, rounded pebble, 7 × 7·5 × 3 cm., and 8 oz.; a large flake has been struck from one end, and two small flakes from the other end to form a concave working edge, 2·5 cm. long, on one corner; the material is grey chert.

No prepared striking platforms are present on any of these cores.

Blocks, karta type.—Two specimens made from thick portions of split pebbles, with outer crust surface and inner cleavage face. E.48691 is quartzite, 8·5 × 8·5 × 5·5 cm., and 20 oz., semicircular in section, with a cleavage face at one end, and a trimmed convex edge at the other end. E.48692 is sandstone, 9 × 7 × 5·5 cm., and 14 oz., with a short trimmed edge at one end. The trimming is from the cleavage surface on both specimens.

Blocks, worimi type.—Two characteristic wedge-shaped specimens. E.48696 is of basaltic stone, 10 × 9 × 5·5 cm., and 24 oz., with semi-discoidal margin, knapped and trimmed at one end from the cleavage surface; it has outer crust and inner cleavage surfaces, and its chord edge bears signs of use. E.48695, of silicified conglomerate material, 10 × 10 × 5·5 cm., and 26 oz., has inner and outer surfaces formed by cleavage faces, and signs of use on its chord edge. It is similar in all respects to the porphyry *worimi* from Anna Bay.

Uniface Pebble Implements.—Three specimens, two of sandstone and one of slate. One is keeled, with a trimmed edge round its semi-discoidal margin, and one has a lateral trimmed margin. One is portion of a split-pebble, with a trimmed lateral margin. They are from 7–9·5 cm. long, 5–7·5 cm. wide, 1·5–5 cm. thick, and 4–14 oz. in weight.

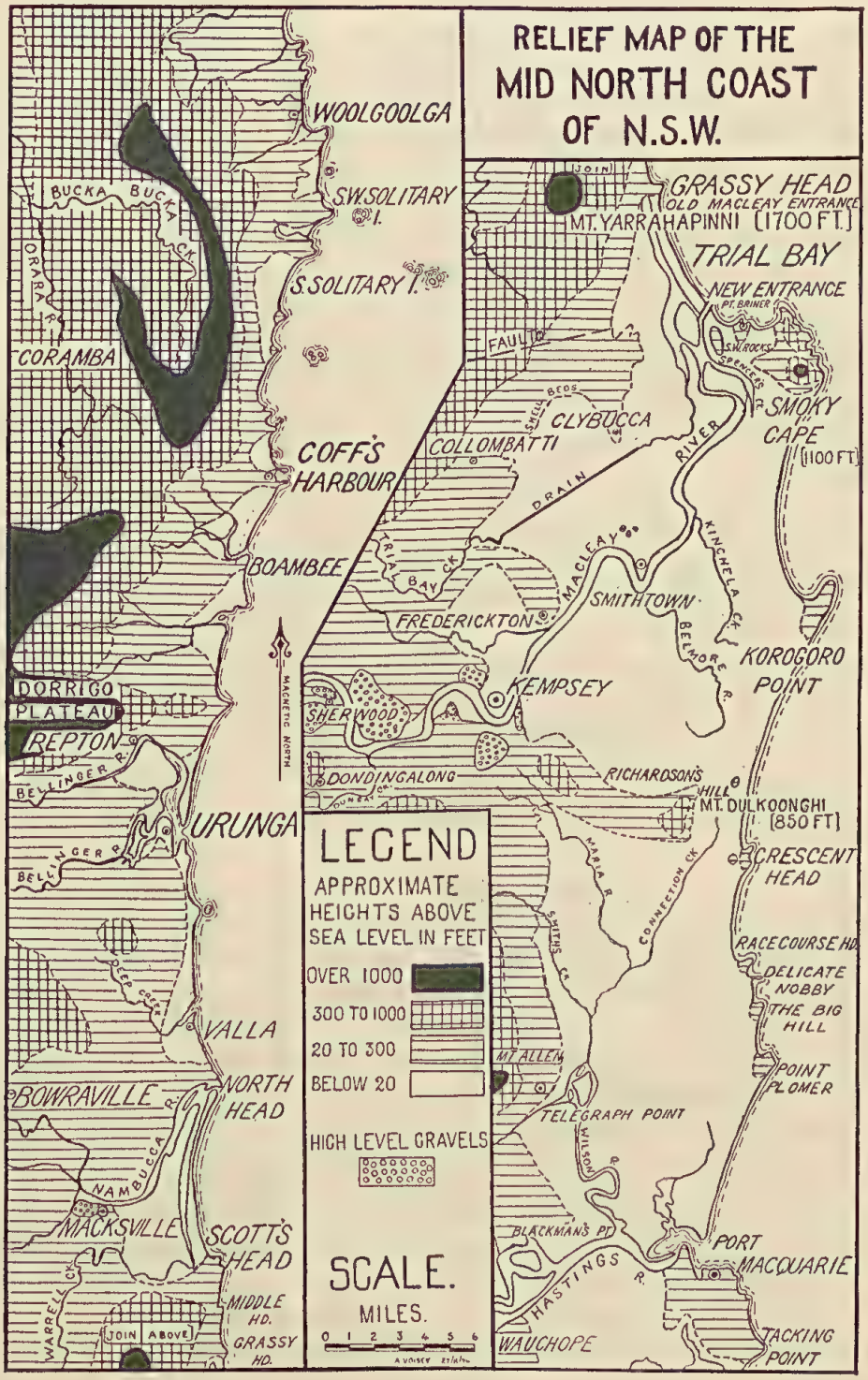

Figure 1.

Blocks.—Three specimens, E.48700–01, E.48704. Elongate and irregular pieces knapped from pebbles, with from straight to convex lateral working edges. They are 8·5 to 10·5 cm. long, 6–12 oz. in weight.

Scrapers.—E.48702 is a side scraper, with a slightly concave edge, and E.48703 has a well used concave edge on one lateral margin. They are 5·5 and 3 cm. long respectively.

Discussion.

Figure 1 is Voisey's map on which is shown the old coast-line prior to the recession of the sea. Professor L. A. Cotton, Department of Geology, University of Sydney, has given me the following statement regarding the antiquity of these kitchen-middens:

During the last stage of the Pleistocene Ice Age in Europe the abstraction of water from the oceans and its accumulation as ice on the sub-polar lands led to a pronounced lowering of sea-level over the whole ocean surface. The date of this condition has been estimated by glacial geologists as about twenty-five thousand years ago. Since that time the sea rose gradually, but there were short intervals during which the level remained stationary or even partly receded. Finally, the rise attained an elevation of rather more than two hundred feet above the level in the glacial period mentioned. Here for a considerable time the sea-level was more or less stable. This condition was maintained for a period sufficiently long for the cutting by wave action of the broad rock benches which flank many of the headlands along the coast of New South Wales. The time required for this must be measured in thousands of years.

While wave action was cutting back the headlands, the detrital material so formed drifted into the bays and made them shallow. In addition, sediments carried into the bays by streams added to the marine deposits and gave rise to shallow tidal flats which were favourable for the development of shellfish. It was at this stage that conditions became suitable for the aborigines to gather the rich harvest of food which is attested by the remains of their kitchen-middens.

A subsequent recession of the sea of ten to fifteen feet put an end to this condition. The age of the kitchen-middens, therefore, lies between the date of the cutting of the rock platforms and the more recent recession of the sea. The date of the latter event has been estimated by Cotton (1926) as from three to five thousand years ago.

It would seem that the greater part of the time from twenty-five thousand years ago to five thousand years ago would be required to cut the rock platforms. If twelve thousand of the twenty thousand years in the interval mentioned be allowed for this process, there would remain eight thousand for the rise in sea-level to two hundred feet to be accomplished, and this may well be sufficient for the necessary melting of the polar ice caps under the influence of an increase in solar activity.

If these speculations be accepted, the kitchen-middens would have accumulated in a period lying between seventeen and five thousand years ago. If we assume that half of this period was required for the development of the mud flats, then the earliest of the kitchen-middens would date back about eleven thousand years.

While there is good evidence for events dated at about five and twenty-five thousand years ago, the records of the interval between these dates can at present be only a matter of conjecture, but it does not seem that the estimate of eleven thousand years can depart widely from the true value.

Thus the importance of these implements lies in the fact that they were made and used by the aborigines of the Kempsey district during the period of the formation of the middens—that is, between eleven thousand and five thousand years ago. The middens were apparently abandoned by the aborigines when the supply of shellfish was cut off because of the drying up of the shallow estuary or lake. Whether the aborigines lived in the district prior to the formation of the shallow basin with its vast supply of mollusc food, and then settled along its shores to take advantage of the harvest caused by the changes in the physiography, or whether they penetrated the area some thousands of years later, cannot be decided, but the extent of the midden deposits indicates a very early occupation of the old coast-line shores. It is probable that ancient kitchen-middens occur at many places where similar changes have taken place along the Australian coast-line generally. Similar pebble implements have been described by Tindale and Maegraith (1931) from an old lake shore at Hawk's Nest, and "apparently associated with a raised beach" at Rainy Creek, on Kangaroo Island, and by Tindale (1937, pp. 52–54) from an old land surface covered by estuarine and marine beds at Fulham, South Australia. They occur as a distinct culture at Yamba and Crescent Head (McCarthy, 1941) and are distributed throughout south-eastern Australia, from Point

Cartwright, Queensland, to South Australia, and are recorded from Tasmania. They have been distinguished as the *kartan* culture by Tindale (1941, p. 145), and form the Hoabinhien I culture in Indo-China, the latter term also being used in the Malay Peninsula and Archipelago. Hoabinhien I is assigned to the beginning of the Mesolithic period by prehistorians of the Far East and Malaya (McCarthy, 1938, pp. 33–38).

Voisey mentioned in his report that human bones have been found in the ancient middens at Collombatti, near Clybucca, and it would be interesting to know whether they are of Tasmanoid or Australoid physical types. It is intended, when conditions permit, to make a detailed investigation of these middens to ascertain the full range of artefacts and associated physical type.

Thanks for the block of Figure 1 is expressed to the Royal Society of New South Wales.

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EXPLANATION OF PLATE XII.

Fig. 1.—Core, E.48688.
Fig. 2.—*Karta,* E.48691.
Figs. 3-4.—*Worimi,* E.48695-48696.
Fig. 5.—Uniface split-pebble implement, E.48698.
Figs. 6-7.—Scrapers, E.48702-48703.

ON A COLLECTION OF OLIGOCHAETA FROM THE JENOLAN CAVES DISTRICT, NEW SOUTH WALES.

By W. Boardman,
Australian Institute of Anatomy, Canberra.

(Figures 1–7.)

The Jenolan Caves are some seventy miles inland from Sydney and lie on the eastern side of the Main Dividing Range at an altitude of 2,600 feet. The surrounding district is rugged, rising in parts to more than 4,000 feet, and is composed of sedimentary and igneous rocks of Silurian age. The specimens which form the basis of the paper were all collected within a radius of five miles of the Caves House. It is a matter for comment that the native forms recorded belong, without exception, to the genus *Megascolex*, despite the fact that the material examined represents the fruits of much intensive collecting. Michaelsen, who visited the area in the summer of 1905, secured a single example of a *Notoscolex*,[1] but apart from this, species of *Megascolex* only have been identified from the region.

My best thanks are due to Dr. A. B. Walkom, Director of the Australian Museum, who placed the material in my hands for examination. Unless otherwise recorded, the specimens were collected by the late Mr. J. C. Wiburd, at one time Superintendent of the Caves.

Family MEGASCOLECIDAE.

Subfamily ACANTHODRILINAE.

Genus Microscolex Rosa, emend. Mich.

Microscolex dubius (Fl.).

Eudrilus (?) *dubius* Fletcher, Proc. Linn. Soc. N.S.W., (2) ii, 1887, p. 378.
Microscolex dubius Michaelsen, Das Tierreich, 10, Oligochaeta, 1900, p. 140.

Locality.—Jenolan, 23 June, 1931; a single sexually mature specimen (W.3321).

Subfamily MEGASCOLECINAE.

Genus Megascolex Templeton.

Megascolex wiburdi sp. nov.

(Figs. 1–2.)

External Characters.—Length 173 mm.; diameter at mid-body 4 mm. Colour purplish-grey dorsally in front of the clitellum; there is a darker mid-dorsal line which persists behind the clitellum (but does not occur on it) as far back as about the middle of the body, where it fades out; the ventral surface and the rest of the dorsal surface practically devoid of pigment. Number of segments 128.

Prostomium epilobous §; the tongue not cut off behind and with its sides converging backwards.

Dorsal pores from furrow 4/5.

The setae are in rings which are interrupted dorsally and ventrally, the ventral break being much larger than the dorsal; they are arranged in regular lines except at the tail end; no pairing is apparent other than with lines of setae *a* and *b* ($ab < bc$). Interval $aa = 3\frac{1}{2}ab$ in front of, and $= 3\frac{1}{3}ab$ behind the clitellum, $= 3ab$ at mid-body, and $= 2\frac{1}{2}$–$3ab$ in the posterior third; zz = ca. $1\frac{1}{2}yz$ in front of the clitellum, $= 1\frac{1}{3}$–$1\frac{1}{2}yz$ throughout the rest of the body, except in the caudal 3–4 cm. where zz may be only slightly greater than yz. The following numbers were counted: 20/v, 20/ix, 20/xii, 24/xix, 24/mid-body, mostly 28–32 at the posterior end.

[1] *Notoscolex jenolanensis* Michaelsen, Abh. Ver. Hamburg xix, 1 Hft., 1907, p. 13.

The clitellum is yellowish-brown in colour and extends over segments ½xiii–xvii (= 4½); narrower across the middle than in front and behind. It is complete all round except where the accessory structures occur on the ventral face of xvii; the glandular tissue is thin in the posterior third of segment xvii. Intersegmental furrows are faintly discernible, setae are present, dorsal pores except 13/14 absent.

The male pores are paired on xviii in *ab*, occurring as nearly transverse slits in line with the setal ring; setae *a* and *b* absent. Each pore opens on the surface of a circular papilla, flattened, and demarcated from the rest of the male field by a shallow raised rim of lighter colour. The male papillae are each set upon a fan-shaped glandular patch which has its apex directed medially, extends in front and behind to the border of the segment, laterally to just beyond *d*; their apices are united across the ventral aspect of the segment by a connecting bar of glandular tissue. Lateral of the male papillae the glandular zone is thicker so that it forms an elevated ridge flanking them. The female pores are paired and closed together, in front of the setal ring, and lie in a slightly depressed oval area which extends laterally to *a*. Spermathecal apertures two pairs, in furrows 7/8 and 8/9; they lie in line of setae *b* and have distinct lips.

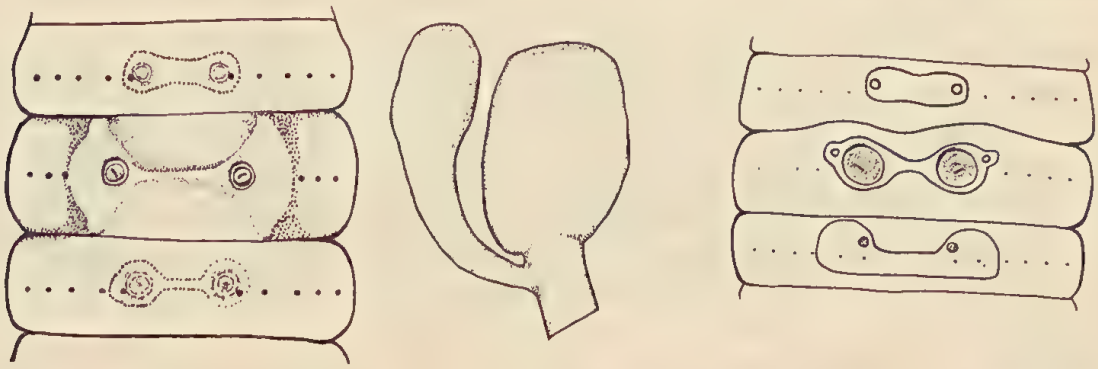

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Fig. 1.—*Megascolex wiburdi* sp. nov. The male genital field (holotype).
Fig. 2.—*Megascolex wiburdi* sp. nov. Spermatheca (holotype).
Fig. 3.—*Megascolex monticola* (Fl.). The male genital field (drawn from the largest of the Jenolan series—W.3307).

Accessory copulatory structures occur on ix, x, xvii and xix. Those on ix take the form of a pair of large gland pores lying behind the setal ring; each extends laterally to *a* or just beyond, medially from *a* for about ¼*aa*; in their immediate vicinity the segment is slightly swollen for an indefinite extent. A pair of similar gland pores is present in *ab* on each side of x, one in front of, one behind the setal ring, the hindmost member slightly nearer the mid-ventral line; a narrow glandular zone surrounds each pore, those on each side coalescing at the line of the setal ring. A glandular patch, the width of which is somewhat less than half of the length of the segment, extends across the ventral face of xvii laterally to between *a* and *b*, its transverse axis in front of the setal ring; it is constricted in the vicinity of the mid-ventral line; a pair of gland pores occurs one on each side, immediately medial of *a*. The structure on xix is similar to that on xvii, but is much more constricted medially so that it appears as a pair of pore-bearing papillae united by a narrow glandular isthmus.

Internal Anatomy.—Septum 4/5 is thin, 5/6 and 6/7 slightly thickened, 7/8 and 8/9 more so; 9/10 to 13/14 are all moderately thickened with little to choose between them; 14/15 is slightly, 15/16 scarcely strengthened.

The gizzard, in segment v, is firm and of medium size. The oesophagus is segmentally swollen in x–xiii, the swelling in xiii being smaller than those in front; there are no calciferous glands. The intestine commences in xvi.

The last hearts are in xii.

The excretory system is micronephridial. Behind the clitellum the tubules are delicate and arranged in transverse segmental rows placed towards the anterior border

of the segment. Corresponding with the clitellar segments they are much more numerous, tend to be matted, and occupy a broad transverse zone in the middle of the segment except in xiii, where the concentration is towards the posterior border. In the three segments between the spermathecal and clitellar regions the nephridia are relatively sparse and arranged in a line across the middle of the segment; they appear to be more robust than those behind the clitellum. From the spermathecal segments forward the tubules become increasingly numerous; they occur very densely and are matted in segments ii–v.

Testes and funnels free in x and xi. The vesiculae seminales are two pairs in ix and xii, of large size and scarcely lobed; the hindmost pair is the larger; they lie lateral of the oesophagus and are in contact dorsally.

The prostates occupy segments xviii–xx, the portion in xx being small; they are deeply lobed where the septa cross them (almost divided by septum 18/19), elsewhere there are a few moderately deep lobes. The duct is stout, shining slightly, and only very little wider in its proximal than in its distal part; its course, traced from the body wall, is caudal and somewhat medial and just before the gland it turns outwards sharply and at right angles to its main direction. The vas deferens joins the duct where it leaves the gland.

The ovaries and funnels are large in segment xiii; ovisacs in xiv.

There are two pairs of spermathecae, in viii and ix. The ampulla is ovoid, sharply defined from the duct; the length of the duct and its diameter are both somewhat more than a third of the corresponding measurements of the ampulla. The single diverticulum is large, stoutly club-shaped, and extends a little beyond the limit of the ampulla; proximally it is curved towards the duct which it joins just below the junction with the ampulla; at its swollen distal end the diverticulum has about the same diameter as the duct. The diverticulum is unrelieved cream in colour, but the ampulla is grey (cf. *M. monticola*).

There are no penial setae.

Variation.—The holotype, described above, is the largest specimen of the series. The thirteen paratypes, all of which, with a single exception, have the clitellum fully developed, show considerable variation in size; the smallest, which has a fully developed clitellum, is only 98 mm. long and correspondingly slender. The male field and accessory copulatory structures are constant in their design and occurrence; the single aclitellate example is practically fully developed in these respects.

Locality.—Mt. George (5 miles from the Caves House); collected by Alec Gilles, 20 June, 1933 (holotype W.3309, paratypes W.3310).

Remarks.—This species is a close relative of Stephenson's *Megascolex rodwayi*, separable by reference to the male field, accessory copulatory structures and the spermatheca. In addition to the affinities indicated for *rodwayi* by Stephenson,[2] both stand close to *monticola*. *M. wiburdi* may be distinguished from *monticola* by the absence of calciferous glands, the male field, and the disposition of the setae.

Megascolex monticola (Fl.).

(Fig. 3.)

Perichæta australis var. Fletcher, Proc. Linn. Soc. N.S.W., (2) i, 1886, p. 565 (specimens from Mt. Wilson).

Perichæta monticola Fletcher, Proc. Linn. Soc. N.S.W., (2) ii, 1887, p. 390 (Mt. Wilson).

Megascolex monticola Michaelsen, Das Tierreich, 10, Oligochaeta, 1900, p. 223. *Id.* Abh. Ver. Hamburg xix, 1, 1907, p. 16, Taf., fig. 11 (mountain slope at Jenolan Caves).

Localities.—Jenolan, 23 June, 1931; 6 immature (W.3304). Head of McKeown's Creek, 6 July, 1931; 1 mature, 1 immature (W.3305). McKeown's Creek, 6 July, 1931; 1 mature, 1 immature (W.3306). McKeown's Creek, 12 August, 1931; 5 mature, 8 immature (W.3307). Jenolan, 8 March, 1932; 2 immature (W.3308).

[2] Stephenson, Proc. Zool. Soc. Lond., 1931, p. 55.

Michaelsen secured a specimen (of which he figured the spermatheca) in the vicinity of the Jenolan Caves in 1905. The series listed above would seem to indicate that the species is common in the district.

There is need for a modernized and amplified account of *Megascolex monticola*. Efforts to locate the types have been unsuccessful. A series of twelve individuals (W.1390) in the Australian Museum collection was secured at Mt. Wilson in November, 1886, that is, during the year prior to the publication of the description; they were identified and donated by the late J. J. Fletcher. None of these specimens had been dissected, but as Fletcher presented all his material to the Australian Museum and no other named *monticola* appear to be in the collection, it is likely that they are part of the original type series. The largest mature example has been selected as a neotype and the following revised description is based upon it.

External Characters.—Specimen discoloured and contracted. Length 132 mm.; maximum diameter (at mid-body) 7 mm.; body cylindrical and tapers slightly from about the middle towards the posterior and anterior ends. Number of segments 151. Distinct secondary annulation absent.

Prostomium epilobous $\frac{4}{5}$; tongue open behind and with median dorsal furrow.

Dorsal pores commence in furrow 5/6.

The setae are in rings and are set in distinct circum-segmental ridges; in front of the clitellum the dorsal and ventral interruptions, particularly the former, are very wide. Setae *a* and *b* are paired in regular lines throughout the body ($ab = \frac{3}{4}$–$\frac{4}{5}bc$), the remainder in more or less irregular lines. The interval $aa = 3\frac{1}{2}$–$4ab$ on segments i–ix, from thence to about the middle of the body = 3–$3\frac{1}{2}ab$, in the caudal half or so = $2\frac{1}{2}$–$3ab$; $zz = 4\frac{1}{2}yz$ in front of, and $2yz$ behind the clitellum, but the latter ratio is variable owing to the irregularity of the lines of setae. Counts are: 16/v, 16/ix, 18(10+8)/xii, 26(12+14)/xix, 24/xxxiv, 26(12+14)/mid-body, and at the posterior end as many as 36 or 39(18+21).

The clitellum is well developed and covers ½xiii–xvii (=4½); it is complete all round except for the ventral portion of xvii occupied by papillae. Intersegmental furrows discernible only ventrally, setae present, dorsal pores visible but almost obscured.

The male pores on xviii are paired in *a*; in line with the setal ring and centrally situated on conspicuous round papillae the dorsal limit of which is in or just ventral of *b*; setae *a* and *b* on each side missing. The area round the base of the male papillae is glandular dorsally about as far as *e*; between and immediately anterior of *b* and *c* there is a duct opening with a slightly tumid flattened rim. The male papillae are connected ventrally by a narrow glandular isthmus with clearly defined edges which gives to the whole a dumb-bell-shaped appearance. Female pores paired and close together in a shallow groove which lies in front of the setal ring and extends laterally to *a*. There are two pairs of spermathecal pores in furrows 7/8 and 8/9 either in or just dorsal of *a*.

Accessory copulatory structures are present on ix, x, xvii, and xix. On ix, in and directed along *aa*, there is on each side of the mid-ventral line a conspicuous slit-like shallow groove with slightly tumid lips; these grooves are within a fairly sharply demarcated raised glandular area which extends as a band across the ventral portion of the segment terminating laterally between *a* and *b*; anteriorly and posteriorly the glandular zone is clear of the segment margin. A pair of well developed glandular pads on x extends from near the mid-ventral line to about half-way between *b* and *c* and from near the anterior to near the posterior segment boundaries, irregularly rounded off laterally and ventrally; on both pads there are two grooves similar to those on ix, one behind the setal ring extending from just ventral of *a* to half-way between *a* and *b*, and the other, in front of the setal ring, placed a little more dorsally; these structures are presumably what Fletcher described as ". . . a pair of 8-like swollen masses on ventral surface of x, with four depressions perhaps pores;". A shallow groove occurs on xvii within *aa* and about equal to *ab* in width, its posterior edge lying

behind the setal ring; within and at each end of the groove, that is, immediately ventral of *a*, there is a small circular papilla (with a central pore) about the same diameter as the width of the groove. A pair of irregular glandular areas on xix overlaps *a* ventrally, extends to about *c* dorsally and is clear of the edges of the segment; they are joined posteriorly by a narrow glandular isthmus; each area has on its medial border a circular flattened papilla in front of the setal ring and extending from about *b* ventrally beyond *a*.

The ventral surface of segments xvii–xix is deeply sunken between *b* and *c* on each side of xviii and xix and between *c* on each side of xvii, making a conspicuous rectangular depression in which the male pores and genital papillae face each other from opposite sides. This depression seems to be an artefact rather than a specific character, since it is very variable in depth in the Mount Wilson specimens and absent in the well-preserved and extended examples from Jenolan (*vide infra*).

Internal Anatomy.—Septa 10/11 and 11/12 very thick, the latter being somewhat the heavier, 12/13 thinner; 8/9 and 9/10 about equal, but thinner than 12/13; 13/14 and 14/15 progressively thinner than 8/9; 7/8 very thin and about the same as 14/15.

The gizzard is large and muscular with a thin-walled dilated crop in front, all in segment v. Calciferous glands are four pairs in segments x–xiii, globular and sessile, attached dorsolaterally to the oesophagus; the hindmost pair is the smallest. Intestine commences in xvi, but does not attain full width till about segment xxiv; in xviii and xix (over the prostates) comparatively slender. Oesophagus swollen in ix.

Last pair of hearts in xii.

The excretory system is micronephridial. The tubules in the spermathecal segments and behind xi are arranged in transverse rows in the middle zone of the segment; they are larger and more numerous in front of, and especially on, the clitellum; anterior of the spermathecae they are dense and matted. In x and xi the nephridia are at the posterior border of the segment and appear to differ in structure from those in front and behind.

Testes and funnels paired and free in x and xi. Two pairs of large seminal vesicles in ix and xii; the anterior pair is placed dorsolateral of the oesophagus, but does not meet above; the posterior pair, finer in texture, forms a ring encircling the oesophagus completely except that the lower extremities do not quite meet beneath.

Prostates paired extending through segments xviii and xix, amorphous; they are bilobed, an irregularly incised lobe in each segment. Prostatic duct in xviii, thick and iridescent, from its distal end posteriorly directed till just before entering the gland when it turns sharply outwards and backwards to form a U-shaped bend. The vas deferens enters the duct just below the gland.

Ovaries and funnels paired in xiii; the ovisacs on the posterior face of septum 13/14 are small, elongate, finely granular bodies circularly disposed near to, and lateral of, the intestine.

Spermathecae are two pairs in viii and ix. The ampulla is large and ovoid with a soft thin wall which shows some transverse wrinkling; duct distinctly defined but very short, scarcely separating the ampulla from the body wall. A single elongate curved club-shaped diverticulum extends distally as far as the end of the ampulla and joins the duct at the body wall; the end is swollen, but not dilated as figured by Fletcher for *M. australis*.[3] The spermathecae agree with Michaelsen's figure[4] except that in my specimens the diverticulum is relatively longer.

Penial setae absent.

Variation.—There are eleven paraneotypes, seven of which either have the clitellum complete or exhibit it in some stage of development, and of these seven the smallest is 79 mm. long and has 148 segments. The grooves in the glandular pads on x show, in a minority of the specimens, some slight variation in position; sometimes they are rounded, particularly the anterior pair. The number of setae varies within comparatively narrow limits. Fletcher, in his description, mentions a case where there were 50 in the

[3] Fletcher, Proc. Linn. Soc. N.S.W., (2) i, 1886, p. 564, pl. ix, fig. 10.
[4] Michaelsen, Abh. Ver. Hamburg xix, 1, 1907, Tafel, fig. 11.

posterior region and Michaelsen[5] records 24 on segments viii and xiii of a specimen he collected at Jenolan, but none of the Mt. Wilson series seems to have quite such high counts on the segments mentioned. In one specimen dissected the prostates occupied xviii–xx.

Remarks.—The revised account differs in some respects from the original description. Fletcher says the clitellum is "of three complete segments, xiv to xvi, and involving a portion of xiii or of xvii, or of both"; in the specimens before me I find that, when fully developed, the whole of xvii is included and about half of xiii. There is also a discrepancy in the position of the spermathecal pores which were recorded as "just ventrad of the first row of setae" and not in or just dorsal of *a*; possibly Fletcher has here made a *lapsus calami* since in mentioning the Mt. Wilson specimens (subsequently separated by him as *M. monticola*) in the description of *M. australis*[6] he says "they [the spermathecal apertures] almost correspond with the interval between the first and second rows on each side, but are nearer to the former". The male pores are stated by Fletcher to occur "on papillæ on xviii, about in a line with 4th row of setæ", but in all specimens examined by me (including those mentioned below) they are in *a*.

The Jenolan Series.—This fine collection provides some additional data on the species. It is noteworthy that the specimens are of much greater size than those from Mt. Wilson. The following details are from examination of the largest individual (one of the batch W.3307):

Length 302 mm., diameter at mid-body 5·5 mm. In alcohol flesh-coloured beneath, grey above in the anterior third of the body, but behind this the pigmentation above gradually narrows till in the posterior half it is merely a dark mid-dorsal line; clitellum lighter than the rest of the body. In front of and immediately behind the clitellum $aa = 2\frac{3}{4}$–$3\frac{1}{2}ab$, $= 3ab$ at mid-body; in front of the clitellum $zz = 3\frac{3}{4}$–$4yz$, $= 3yz$ on xviii and from thence backwards *zz* narrows rapidly so that a dozen or so segments behind the clitellum it is only slightly greater than *yz* and this relationship persists through the rest of the body. The counts are: 20/v, 22(10+12)/ix, 20/xii, 30(14+16)/xix; at mid-body there are from 14 to 18 setae per side, usually a couple more on one side than on the other so that, in general, the total for the ring is most commonly 30 or 32. There are no accessory copulatory structures on ix; on xvi a small, not well defined, glandular patch of triangular shape lies on the ventral face of the segment; it is within *aa* and the apex of the triangle points towards the tail. The absence of accessory copulatory structures on segment ix is general in the Jenolan series. Michaelsen did not record them in his specimen. Those on x, however, are consistently present and are readily recognizable even in quite small immature examples. The relative length of the diverticulum of the spermatheca is similar to that figured by Michaelsen; the curious grey colour of the spermathecal ampulla which was commented on by Michaelsen is a conspicuous feature of the internal anatomy of all mature specimens examined (this was not observed to occur in the Mt. Wilson series).

It would seem that there is a distinct race of *M. monticola* in the Jenolan district distinguishable by large size, the absence of accessory structures on ix and, possibly, the characters of the spermatheca.

Megascolex rodwayi Steph.

Megascolex rodwayi Stephenson, Proc. Zool. Soc. Lond., 1931, p. 53, text-fig. 8.

Localities.—Top of Cave Hill, 4,200 feet, 6 July, 1931; 5 mature, 5 immature (W.3311). McKeown's Ck., same date; 2 mature (W.3312). Head of McKeown's Ck., same date; 4 mature, 4 immature (W.3313). McKeown's Ck., 12 Aug., 1931; 1 mature (W.3314). Above the caves, Jenolan, 15 Sept., 1931; 3 mature, 2 immature (W.3315). Mt. George (5 miles from the Caves House); coll. Alec Gilles, 20 June, 1933; 10 mature, 1 immature (W.3316).

[5] Michaelsen, Abh. Ver. Hamburg xix, 1, 1907, p. 16.
[6] Fletcher, Proc. Linn. Soc. N.S.W., (2) i, 1886, p. 562.

Remarks.—Stephenson described *rodwayi* from Hampton, which is some thirteen miles north of Jenolan. The specimens before me provide additional data on variation within the species, particularly with respect to the genital markings.

The setal count for segment xix was often found to be 22(10+12) and not infrequently 24. At the posterior end, for about the terminal twenty segments, considerable irregularity in the arrangement of the setae was noted, with the count as high as 30 to 36.

The male papillae on xviii are most usually united by a narrow glandular isthmus giving to the male field a dumb-bell-shaped outline; this isthmus may be weakly developed or apparently absent. The female pores are paired and lie close together in front of the setal ring.

Stephenson notes the presence of "small, round, darker spots" associated with the genital markings recorded. In all the specimens from Jenolan these spots occur as described, but are lighter in colour than the surrounding tissue. The spots (probably indicating openings of gland ducts) are always placed anterior of the setal ring and lie at the centre of the small circular glandular patches which, when not near enough to be confluent medially, are, in the case of those on and behind the clitellum, united by a narrow glandular bar the transverse axis of which lies behind the line joining the two spots. In the series of pairs of patches behind segment xviii (which may be more numerous than described by Stephenson) each is nearer the mid-ventral line than the one preceding it. The markings on xi, xvii, xix, xx and xxi are generally present (in one mature specimen there were no patches on xxi), those on xvi may be absent or weakly developed, whilst those on x were found in only a minority of cases; often there are markings on xxii, less frequently on xxiii, and one example has them on xxiv; one specimen shows markings on xii and xiii in addition to x and xi, and in another in which they are absent on x the left member of the pair on xi appears to have become displaced backwards onto xii.

The segmental swellings of the oesophagus in x–xiii are a conspicuous feature of the internal anatomy; the one in xiii is smaller than the other three. There is an additional pair of vesiculae seminales in x; they are small, granular and elongate, attached to the anterior face of septum 10/11, and lie lateral and somewhat dorsal of the alimentary canal. The diverticulum of the spermatheca is often longer than figured by Stephenson, but in no specimen examined did it extend distally as far as the ampulla.

Megascolex crateroides sp. nov.

(Figs. 4–5.)

This species is established on a single specimen in which the clitellum appears to be not fully developed.

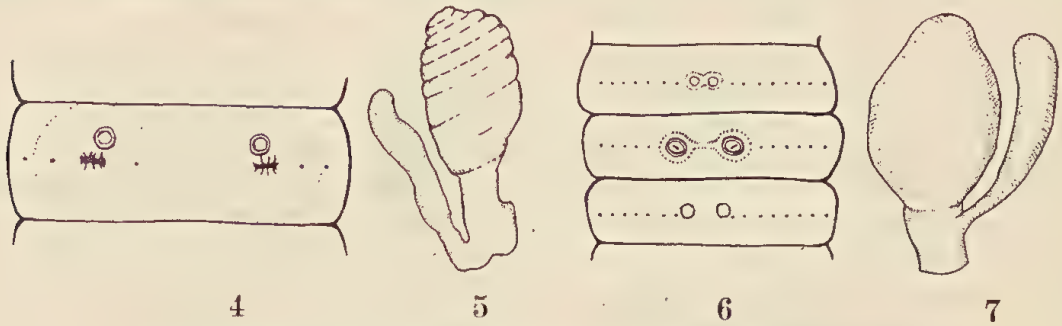
External Characters.—Length 145 mm., diameter at mid-body 3 mm. Colour in general a pale cream. Number of segments 130.

The prostomium is epilobous $\frac{3}{5}$; tongue open behind, its sides converging backwards. Dorsal pores from furrow 4/5.

The setae are arranged in dorsally and ventrally interrupted rings, the dorsal break being slightly the larger. Interval *aa* = 2*ab* in front of the clitellum, = slightly less than 2*ab* immediately behind the clitellum, and in the remainder of the body = $2\frac{1}{2}ab$; *zz* = $1\frac{1}{2}$–$1\frac{3}{4}yz$ in front of the clitellum = $1\frac{1}{2}$–$2yz$ behind the clitellum and as far back as the commencement of the caudal third in which *zz* = 2–$2\frac{1}{3}yz$. In general, the lines of setae are in somewhat irregular lines, but *a* and *b* are paired and in regular lines; owing to the irregularity of line of setae *c*, *ab* may be equal to or slightly greater or less than *bc*; no other pairing among the setae was observed. The following numbers were counted: 16/v, 17(8+9)/ix, 19(10+9)/xii, 20/xix, about 20 at mid-body, this number being commonly plus or minus 2.

The clitellum is insufficiently developed for the limits to be defined accurately; most of xiii and back to xvi ($= 3\frac{1}{n}$) appears to be involved, but the differentiation of clitellar tissue is not very marked. Dorsal pores, furrows and setae are all visible on the segments recorded.

The male pores are paired on xviii and are situated at the summits of low conical swellings (they could scarcely be called papillae) which occur one on each side of the mid-ventral line; these swellings are of indefinite outline and extend from slightly medial of *a* laterally to about *d* and from border to border of the segment; between



4 5 6 7

Fig. 4.—*Megascolex crateroides* sp. nov. The male genital field.
Fig. 5.—*Megascolex crateroides* sp. nov. Spermatheca.
Fig. 6.—*Megascolex jenolanensis* sp. nov. The male genital field (holotype).
Fig. 7.—*Megascolex jenolanensis* sp. nov. Spermatheca (paratype).

them (judged by the relative visibility through the skin of the nerve cord) the body-wall is thicker than in the corresponding position on xvii and xix. The male pores are large and take the form of a transverse slit, the lips of which are much puckered; they are in *bc*, their most medial limit lying almost in *b*. In front of the male pores on the slope of the cone and in *b*, that is, medial of the centre of the male pores, there is a small circular raised glandular ring (probably the opening of a gland pore). On the right side of the male field seta *a* is present. The female pores are paired and open very close together on xiv in front of the setal ring. The spermathecal apertures are three pairs with slightly tumid lips lying normally intersegmentally between lines of setae *c* and *d*, but nearer to *d*; the presence of additional setae, however, may place them apparently between *d* and *e*.

There are no accessory copulatory structures present.

Internal Anatomy.—Septa 5/6–7/8 are slightly thickened; 8/9–13/14 are somewhat thicker, 10/11 and 11/12 being thicker than the rest; 14/15 and 15/16 about the same as 7/8 and 6/7 respectively.

The gizzard, in segment v, is large, firm and muscular; the oesophagus in front of the gizzard was found to be invaginated backwards into it. Behind the gizzard as far back as segment xv the oesophagus is wide and thin-walled and shows some not very marked segmental swelling, especially in xii–xiv; in xv and xvi there is a progressive and conspicuous narrowing of the oesophagus. There are no calciferous glands. The intestine begins in xvii.

The last hearts are in xii.

The excretory system is micronephridial. In the pharyngeal region the nephridia are tufted, the tufts converging towards the anterior borders of the segments; there is a large tuft in v and a smaller one in iv; in vi the nephridia nearer the mid-ventral line are larger than those more laterally placed and show a tendency to tufting. In segment xiv and in those which follow it the tubules are very small and are arranged in each segment in two narrow transverse bands, one at the anterior and one at the posterior border of the segment. In xiii and the segments which precede it the band of nephridial tubules is present only along the posterior border; in the spermathecal segments there are, in addition, scattered tubules in the ventral portion of the segment which have a tendency to be aggregated towards the anterior border. The tubules in front of xvii appear to be less delicate than those further back.

Testes and funnels free in x and xi. Vesiculae seminales are present in xi and xii attached to the posterior face of septum 10/11 and 11/12 respectively; the pair in xii, though of only moderate size, is four or five times as large as the more anterior pair. Both pairs of vesiculae seminales are finely granular and close in texture and are

elongated dorsoventrally so that they lie lateral of the oesophagus and do not meet either above or below it.

The prostates occupy segments xviii and xix. They are flattened, of irregular outline, and have their borders much but shallowly lobed. The left prostate in xix has its lateral border produced outwards as a conspicuous lobe; the same feature is present in the right prostate, but in xviii. From the disposition of these lobes and the ducts it would appear that, in the course of development, one prostate or the other (probably that on the right side) has been turned through half a circle on its dorsoventral axis. The prostatic duct leaves the gland on the left side near its anterior end, near the posterior end of that on the right; the duct follows an S-shaped course which takes it backwards and medially to the body-wall, the long axis of the S being approximately parallel with the long axis of the body. The junction of the vas deferens with the duct was observed only on the left side where it took place some distance below the gland; distal to this point the duct is thin-walled and soft, but proximally it is thicker, shiny and muscular, and widens slightly as it proceeds to the body-wall.

The ovaries and funnels are in segment xiii. Ovisacs are present in xiv.

There are three pairs of spermathecae. The ampulla is ovoid with a series of more or less irregular latitudinal grooves; it is clearly demarcated from the duct. The duct is half or somewhat less of the length of the ampulla and two-fifths of its greatest diameter; proximally, on the side opposite where it is joined by the diverticulum the duct presents a conspicuous swelling which, in a cleared preparation, is seen to be a sessile sac communicating with the duct by a small orifice. The diverticulum is tubular, rounded distally, and narrows for a short distance proximally before joining the duct below the level of the body-wall; at its wide part it is about three-fifths of the width of the duct of the ampulla and extends outwards to almost half-way along the ampulla. In one spermatheca the diverticulum was very narrow with a spherical swelling at its distal end.

Penial setae are not present.

Locality.—Mt. George (5 miles from Caves House), 20 June, 1933; collected by Alec Gilles (W.3320).

Remarks.—The unusual form of the male apertures makes *crateroides* readily separable from other species of the genus with three pairs of spermathecae. It is related through its setae and spermathecae to *M. austrinus* and *wilsonianus*.

Megascolex jenolanensis sp. nov.

(Figs. 6–7.)

External Characters.—Length 135 mm.; diameter at mid-body 3 mm. Colour in alcohol uniform cream. Segments 106 (the tail end appears to have regenerated); secondary annulation absent.

Prostomium epilobous $\frac{3}{4}$, tongue open behind and tapers posteriorly.

Dorsal pores commence in furrow 5/6.

Setae perichaetine with the rings dorsally and ventrally interrupted; in regular lines before the clitellum, some irregularity behind it. The two ventralmost setae on each side persist as a pair throughout the body; $ab < bc$ on and in front of the clitellum and mostly, but not invariably, behind it. The numbers are: 23(11+12)/v, 24/ix, 26(14+12)/xii, 26/xix; the mid-body count is most commonly 24, but not unusually there are less than twelve to a side and occasionally one or two more. $aa = 3ab$, $zz = 2–2\frac{1}{2}yz$ in the body generally.

Clitellum $\frac{1}{2}$xiii–xvii (= $4\frac{1}{2}$), deeper in colour than the rest of the body; dorsal pores absent, except that in furrow 13/14, furrows defined ventrally, setae present.

The male pores are paired on xviii in *a*, have the form of nearly transverse slits, and on each side open on a depressed circular papilla which is surrounded by a ring of glandular tissue raised above the general surface of the body and extending laterally to about half-way between *b* and *c*, medially beyond *a* so that the opposite members are separated ventrally by about 2 *ab*; anteriorly and posteriorly the rings do not reach

the borders of the segment. A narrow isthmus of raised glandular tissue traverses the ventral face of xviii, joining the two structures so that the glandular zone of the male field has the appearance of a dumb-bell. Female pores occur paired on xiv in front of the setal ring. There are four pairs of spermathecal pores in furrows 5/6–8/9 in *ab* mostly nearer to *b*; the openings are small transverse slits with tumid lips.

In *aa* on xvii and xix there is a pair of small circular flattened papillae each with what appears to be a gland opening at its centre; the pair on xvii is contiguous medially and lies in the line of the setal ring, those on xix are slightly in advance of the setal ring and are about 1½*ab* apart. There is a pair of gland openings on each side of segment x, the area in their immediate vicinity being considerably swollen; of the two pores on each side one is anterior, the other posterior, to the setal ring, the former lying in *ab*, the latter in *a*.

Internal Anatomy.—Septa 7/8–15/16 all show thickening; the group 9/10–12/13 is considerably stouter than the rest, 11/12 being the thickest, though not by very much; 10/11 and 12/13 about the same. There is progressive thinning back from septum 12/13 and forward from 10/11.

The gizzard in segment v is very large and muscular; it is an elongate tulip-shape generally, narrowing posteriorly. The oesophagus in front is swollen to the same diameter as the gizzard for a distance equal to about a third of its length and thus forms a crop. The posterior end of the gizzard extends back almost to furrow 9/10 so that septa 5/6–8/9 are greatly invaginated by, and surround it. Calciferous glands are present in x–xiii (= 4); they are kidney-shaped, sessile, laterally placed with reference to the oesophagus and are contiguous dorsally. The intestine begins in xvi.

Last hearts in xii.

Excretory system micronephridial. The tubules are irregularly scattered on the body-wall, sparser in segments viii–xii, numerous in v–vii. In the hindmost twenty segments the number of micronephridia increases greatly, so that they tend to be matted in some segments.

Testes and funnels free in x and xi. Vesiculae seminales in ix, x and xii, not large, finely granular; those in ix and xii are about equal in size and lie lateral of the oesophagus; the pair in ix is in the form of an irregular lump, those in xii are crescentic in outline; in x they are very small (being easily missed in dissection), are attached to the anterior face of septum 10/11 and lie dorsolaterally above the intestine.

The prostates are compact, flattened and lobed, occupying xviii and xix on the left side, xviii–xxi on the right. The duct is short, shining and thick, passing first transversely inwards and then at about the middle of its length curved sharply to run anteriorly and laterally before entering the body-wall. The vas deferens joins the duct where it leaves the gland.

Ovaries and funnels in xiii; ovisacs in xiv.

There are four pairs of spermathecae, the last in segment ix. They have a large spherical ampulla demarcated from the duct which is short and thick, and about a third of the length of the ampulla. The diverticulum is stout and club-shaped, curved somewhat and narrows as it approaches attachment to the duct which it joins at the level of the body-wall; it extends outwards to the same distance as the ampulla.

There are no penial setae.

Variation.—There are five clitellum-bearing specimens in addition to the holotype (which is described here), the lengths of which are 105, 128, 134, 140 and 141 mm.; the number of segments varies between 128 and 135. In one specimen a zone commencing at segment xxvi and extending for about a quarter of the body length is triannular. The setal formulae laid down above are subject to some fluctuation; *aa* may equal as much as 3½–4*ab* and *zz* may be only 1½*yz*. The configuration of the male field is very constant; sometimes the glandular bar connecting the two papillae is only faintly delineated. The papillae on xvii may be distinct (in which case a narrow raised bar of glandular tissue joins them in a manner similar to that found with the male pores) or they may show varying degrees of fusion from merely touching to the

loss of their separate identity. A further pair of small papillae with a central gland opening occurs in one specimen on segment xvi (another specimen has the structure weakly developed on one side); they are similar to those on xvii, but smaller and nearly touch medially. The condition of the accessory structures on segment x as described in the holotype seems to be typical, though some specimens present differences in detail and degree of development.

The ampulla of the spermathecae may be ovoid or spherical, and the diverticulum may extend outwards from about two-thirds of the length of the ampulla to slightly beyond it.

Locality.—Top of Cave Hill, 4,200 feet; two series collected on 6 July, 1931 (includes the holotype—W.3317, plus 4 mature and 6 immature paratypes—W.3318), and 15 Sept., 1931 (1 mature and 2 immature examples—W.3319), respectively.

Remarks.—The species is very closely related to *Megascolex fecundus* (Fl.) described from Mt. Wilson and Lawson in the Blue Mountains. It is unlike it, however, in a number of points, most striking among which is the condition of the accessory copulatory structures. In *fecundus* there is an additional pair of calciferous glands and hearts, but no vesiculae seminales have been recorded in segment x; both number of segments and size are less than in *jenolanensis.*

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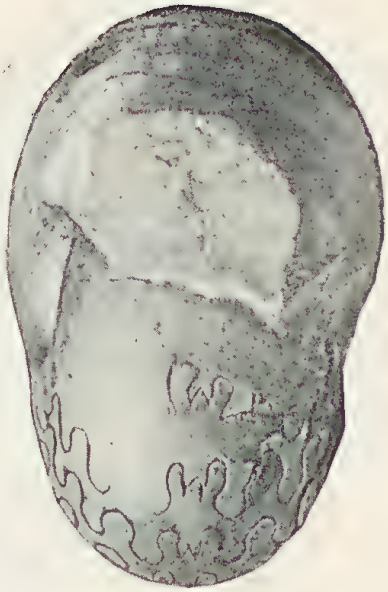

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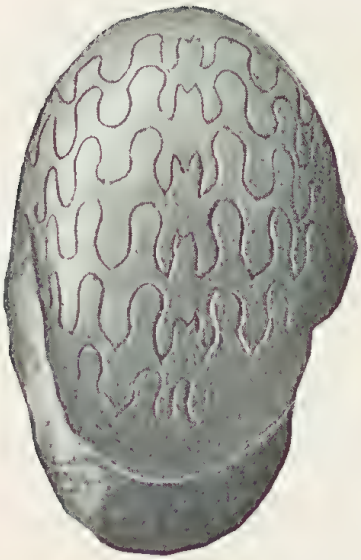

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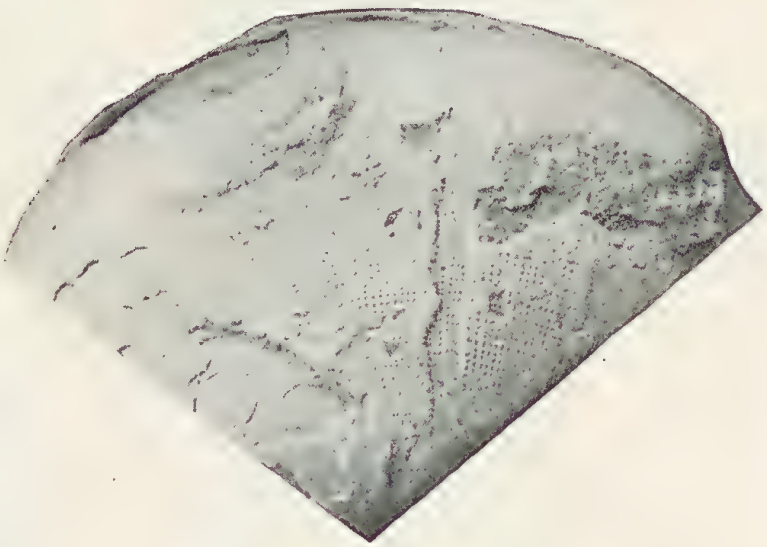

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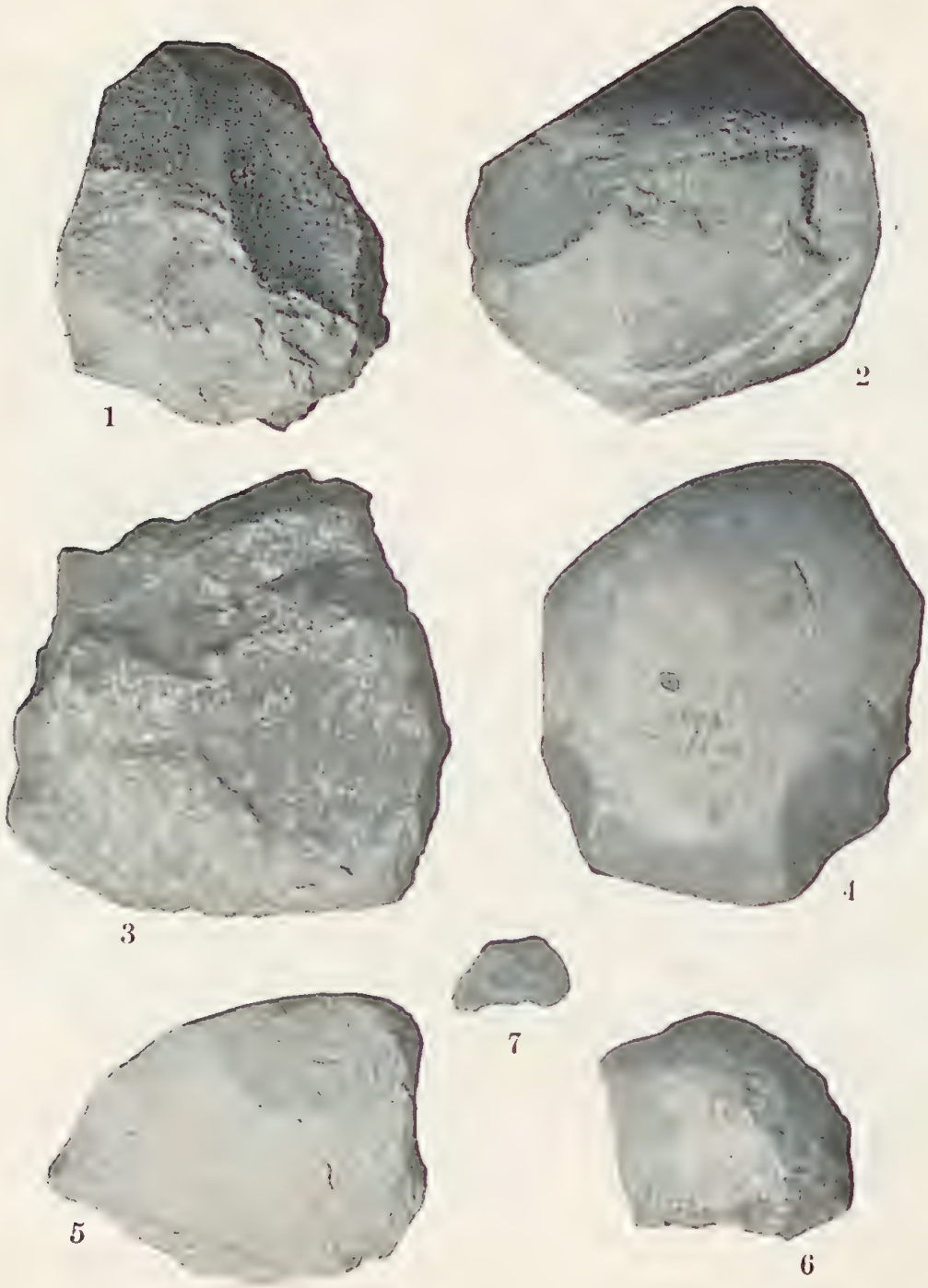
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A NEW SPECIES OF *TERPNA* FROM NATIONAL PARK, NEW SOUTH WALES.

(Lepidoptera: Geometridae.)

By the late G. M. Goldfinch.

Terpna olivia, n. sp.

Male: 31 mm.

Forewing: 7, 8, 9, 10 stalked from cell; 6 connate with the stalk of 7, 8, 9, 10; 11 from cell and separate.

Face bluish-green; lower margin with a dark brown line narrowly edged with bluish-green scales; vertex bluish-green.

Palpi: basal segment whitish with a black streak near apex, mixed with red scales; second segment black mixed with red scales, lower edge with whitish scales. Terminal joint black, rather short.

Antennae: basal joint bluish-green with notch as in *hypochromaria*, shaft reddish, with irregular fuscous rings, pectinations fuscous; towards the apex simple.

Thorax: tegulae bluish-green with a black spot at the base; patagiae bluish-green with central area with scattered black and red scales. Abdomen bluish-green with scattered black scales, laterally yellow. Two green tufts of scales on 4th and 5th segments. Tuft yellow.

Legs: anterior and median yellowish with red and fuscous scales, tarsi fuscous, ringed at joints with yellow; posterior pair yellow.

Forewings: bluish-green with scattered darker green scales, costal edge strigulated with black, lines black; a short black dash near base of costa; first line from costa at one-fourth to dorsum beyond one-third, somewhat waved, distally broadly suffused, enclosing reddish and darker green scales. A square black spot beneath costa at one-half. Second line from costa at three-fourths, black edged with scattered red scales, interrupted between veins 6/7, and ending on vein 3 and indicated by a small black spot on vein 2. A small blackish spot on costa before apex.

A large irregularly shaped suffusion consisting of fuscous mixed with reddish-brown scales.

Terminal line absent except between veins 2/3 and 4/5.

Hindwings: bluish-green with scattered darker green scales; first line absent. Second line from below costa at two-thirds, first outwards, then inwards curved to vein 4, then straight to dorsum at two-thirds.

An obscure suffusion, blackish and reddish scaled, from below costa at one-half, outwards curved and joining second line in middle. A similar bar-shaped suffusion from near second line in middle to near margin.

Underside: yellow, broadly suffused with pinkish scales. First line black. Discal spot round, black. Second line black, followed by an extensive black suffusion surrounded with red scales.

Hindwing: first line and discal spot absent; second line a series of loosely connected reddish spots followed by a broad red suffusion.

N.S.Wales: National Park, Sydney, March, 1938, 1 ♂.

This beautiful species is named in honour of my wife, who has been my companion and help on so many collecting expeditions.

Holotype male in the Australian Museum, Sydney. Reg. No. K.67629.

UPPER PERMIAN HOMOPTERA FROM NEW SOUTH WALES.

By J. W. Evans, M.A., D.Sc.

(Figures 1–64.)

In the twenty-five years which have elapsed since the first descriptions were published of Upper Permian Homoptera preserved in volcanic tuff in New South Wales, much new and interesting material has been brought to light. Former collections have been described by Tillyard (1921, 1922, 1926*a*), Davis (1942) and Evans (1943).

The present collection, comprising some 124 specimens, has been made principally by Mr. Malcolm Stanley. A few specimens, comprising some of the very greatest interest, have been contributed by Mr. O. le M. Knight. Both Mr. Stanley and Mr. Knight have generously presented their material to the Australian Museum.

It is but seldom that a taxonomist interested in recent insects is given the opportunity to study new fossil material in his chosen group, and appreciation and thanks are expressed to the Director and Trustees of the Australian Museum for having afforded me this privilege.

Unless otherwise indicated, all specimens dealt with in this paper were found in Upper Permian strata between Belmont and Warner's Bay and are contained in the Malcolm Stanley collection of fossil insects at the Australian Museum, Sydney. The photograph reproduced in Fig. 24*a* was made available by Mr. Knight.

Division PALAEORRHYNCHA.

Family ARCHESCYTINIDAE.

In a recent paper (Evans, 1943) a remarkably preserved small Homopteron from the Upper Permian of Belmont (*Permocephalus knighti* Ev.) was placed in the Archescytinidae. This was an error, the result of confusion induced by the following circumstances. In 1926, Tillyard (1926*b*) erected a new family, the Permopsyllidae, in which he placed a single genus, *Permopsylla* Till. The genotype, *P. americana* Till., was found in Lower Permian strata in Kansas. Tillyard, following a definition of the family, stated that it was a specialized offshoot from the Archescytinidae which had undergone reduction in size and in the length of the tegmen compared with its breadth, together with great reduction in the clavus. The latter character Tillyard considered brought the type of wing definitely within the Sternorrhyncha. In the same year (Tillyard, 1926*a*) he described three more genera, *Permothea*, *Protopsyllidium* and *Permopsyllidium*, all from Upper Permian strata in New South Wales, and these he also included in his family Permopsyllidae.

In 1931 Carpenter transferred *Permopsylla* to the Archescytinidae and pointed out that the reduction of the clavus was more apparent than real, due to the incomplete preservation of the type specimen. For this family he proposed a new division, the Palaeorrhyncha. Insects in the Palaeorrhyncha, according to Carpenter, combine primitive features of both the Auchenorrhyncha and the Sternorrhyncha, as Archescytinids were furnished with long antennae, consisting of twenty-five segments; three-segmented tarsi and a fully developed clavus in each tegmen with two anal veins. At the same time he proposed the family name Protopsyllidiidae for the genera *Permothea*, *Protopsyllidium* and *Permopsyllidium*.

Davis, in 1942, referred to Carpenter's action in transferring *Permopsylla* to the Archescytinidiae, but apparently overlooked the new family name Protopsyllidiidae, as he continued to include the three genera from New South Wales previously defined

by Tillyard, in the Permopsyllidae and at the same time added a further five genera to the same family.

Permocephalus was originally placed in the Archescytinidae, as it was erroneously supposed that this family was identical with the Permopsyllidae of Tillyard. *Permocephalus knighti* has short antennae and is related to species in genera comprised in the Protopsyllidiidae, not to *Permopsylla* spp. It is accordingly transferred from the Archescytinidae to the Protopsyllidiidae.

Thus, up to the present, no true Archescytinids have been described from the Upper Permian of New South Wales. Two specimens in the present collection would seem to belong to this family. One is described below; the other, a fragment, is figured in a later section (Fig. 59).

Austroscytina, gen. nov.

The hind-wing is of stout consistency and the costal space is narrow. R_{1a} meets the costal margin only slightly beyond its centre. R_{1b} does not extend as far as the apex of the wing and the space separating the apices of R_{1a} and R_{1b} along the costal margin is only slightly greater than the space between R_{1b} and Rs. M has three branches, and M and Cu_1 have separate origins. The clavus is unknown.

Austroscytina imperfecta, sp. nov. (Genotype.) (Fig. 3.)

Length of wing, 8 mm.; greatest width, 3·3 mm. The dotted line shown in the figure occurs as a furrow in the wing in the position indicated. It may represent Sc.

Holotype wing—F 40084, Malcolm Stanley Collection.

Division AUCHENORRHYNCHA.

Family PROSBOLIDAE.

Three tegmina and one wing, from the Upper Permian of New South Wales, have been ascribed previously to this family. They are of *Mitchelloneura permiana* Till. (1921), and *Permoglyphus belmontensis* Till., *Permodiphthera robusta* Till., and *Permodiphthera dubia* Till. (1926*a*).

In describing the family characteristics, Tillyard states that there is a differentiation in the texture of the membrane of the basal and distal portions of the tegmen and that the costa may be notched either at, or before, the apex of R_{1a}, forming a kind of nodus.

In *Prosbole hirsuta* Handl. from the Upper Permian of Russia, the tegmen is divided into two parts as described by Tillyard. However, the nodal line in all those Russian Prosbolidae in which it is present, invariably extends from where R_{1a} meets the costa[1] to the point where M first branches, thence to the fork of Cu_1. Martynov (1935*b*) has grouped also in this family certain tegmina which lack all trace of a transverse division.

It is suggested that the "nodal lines" indicated in Tillyard's figures of *Permoglyphus belmontensis* and *Permodiphthera robusta* are merely creases, the result of slight crumpling. Accordingly, *Permoglyphus* Till. and *Permodiphthera* Till. are transferred from the Prosbolidae to a new family, the Permoglyphidae. *Mitchelloneura* Till., being known only from a hind-wing, is retained in the Prosbolidae.

Martynov (1928) has suggested that the genera *Orthoscytina* Till. and *Homaloscytina* Till., placed by Tillyard in the Scytinopteridae, belong rather to the Prosbolidae. This suggestion is not supported.

Austroprosbole, gen. nov.

The tegmen is long, broad and delicate. A break occurs in the costal margin where it is in contact with R_{1a}, and there is a distinct nodal line in the position indicated in the illustration of the tegmen of the genotype. The costal space is wide, and Rs is bent and in close contact with M_1. M has four branches, and M_1 and M_2 are shorter than M_3 and M_4. The clavus is broad, the two anal veins meet at their distal apices, and the anal margin is not in alignment with the rest of the hind margin of the tegmen.

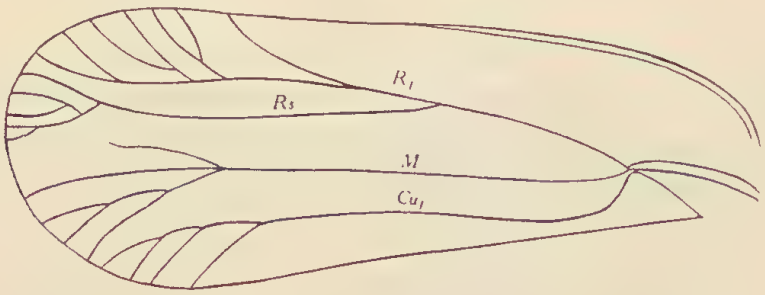
[1] The costa may be interrupted at R_{1a} without the development of a nodal line, as for instance in the recent Psyllid, *Cometopsylla rufa* Frogg. (Froggatt, 1900).

Austroprosbole maculata, sp. nov. (Genotype.) (Fig. 2.)

Length of tegmen, 13 mm.; greatest width, 5 mm. The whole tegmen has a mottled colour pattern and no apparent differentiation in texture.

Holotype tegmen—F 40048, Malcolm Stanley Collection.

In all other known Prosbolidae, with the exception of *Dictyoprosbole membranosa* Mart. (Martynov, 1935*a*), the anal veins are distinct for their entire length, but reasons exist for believing that the presence or absence of a V- or Y-vein in the clavus is a character of limited significance.



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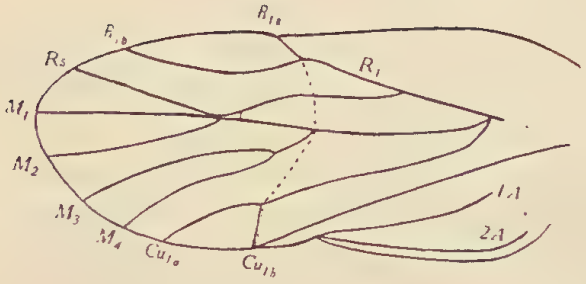

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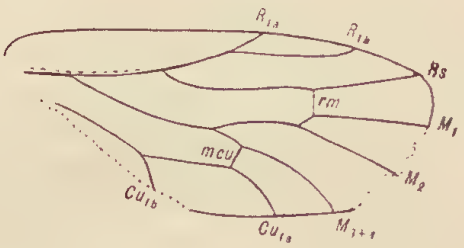

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Figs. 1-3.—1, *Permobrachus magnus*, holotype tegmen. 2, *Austroprosbole maculata*, holotype tegmen. 3, *Austroscytina imperfecta*, holotype tegmen.

Tillyard (1918) suggested that species in the Triassic family Dunstaniidae were related to the Permian family Prosbolidae and at the same time ancestral to the Heteroptera. In 1926 (1926*c*) he confirmed his former hypothesis and stated that "the family Dunstaniidae belongs to the Gymnocerata and is clearly an early type ancestral to the Pentatomoidea". In the same year (1926*a*) he had already written that the Prosbolidae appear to have been ancestral to recent Fulgoroidea, especially the Trophiduchidae. It is agreed that the Prosbolidae may have been on the same line of descent as the Fulgoroidea, as might equally well have been the Permoglyphidae and Pereboridae,[1] but the mere tendency of a tegmen to divide into a coriaceous proximal portion and an overlapping membranous distal part does not necessarily imply any ancestral relationship with the Heteroptera. On another occasion, Tillyard (1936) figured a Triassic tegmen which he stated was "a specialized Scytinopterid type in process of becoming a true Heteropterous type". The only explanation offered in support of such a startling pronouncement was the shape of the tegmen, which was not unlike that of a recent Achilid.

[1] The closest approach to a Fulgoroid type, of any known Australian Permian Homoptera, is to be found in the tegmen of *Eochiliocycla angusta* Davis, which should be compared with recent Achilids.

Family PERMOGLYPHIDAE.

This family has characteristics in common both with the Scytinopteridae and the Ipsviciidae. *Permoglyphus belmontensis* resembles the former in the shape of the tegmen, in the shape of the proximal half of Cu_1, in having a complete media with four branches, and in the complete separation of the anal veins. It resembles *Paraknightia magnifica*, gen. et sp. nov. (Ipsviciidae), in the short transverse Sc, in the transverse nodal break which extends from the costa, to the point of separation of R and M from R + M, in having R parallel with the costal margin, and in the possession of separate anal veins. *Permodiphthera robusta*, *Permodiphthera dubia* and *Permobrachus magnus*, gen. et sp. nov., lack certain of these characteristics, but all have Rs with more than a single branch, and for the moment it is convenient to group them together with *P. belmontensis*. Tillyard suggested that *P. dubia* might not be congeneric with its genotype. It is now transferred to the new genus *Permobrachus* which is described below. *Permobrachus magnus* resembles *Permopibrocha ramosa* Mart. (fam. Pereboridae) in the development of numerous subsidiary veins and it is possible that it would be better placed in this family.

Permobrachus, gen. nov.

(Genotype, Permobrachus dubia (Till.).)

The tegmen is long and somewhat narrow. R, Rs, M and Cu_1 all have subsidiary veins. Cu_1 is curved following its separation from R and M, and the costal space is extensive. The clavus is unknown.

Permobrachus magnus, sp. nov. (Fig. 1.)

Length of tegmen, 16 mm.; greatest width, 5·8 mm. The proximal third is somewhat roughened and the apical two-thirds smooth. This effect is believed to be due to the manner of preservation and not to a difference in the consistency of the original tegmen.

Holotype tegmen—F 40029, Malcolm Stanley Collection.

Family SCYTINOPTERIDAE.

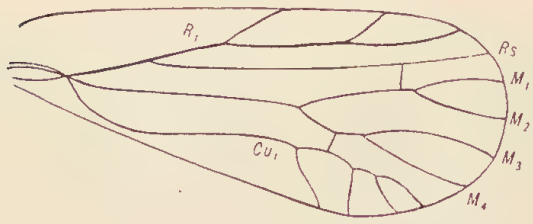
The following genera of Upper Permian Homoptera from New South Wales have been placed in this family by their respective authors: *Permoscarta* Till., *Permojassus* Till., *Stenoscytina* Till., *Orthoscytina* Till., *Actinoscytina* Till., *Elliptoscarta* Till., *Homaloscytina* Till., *Psocoscytina* Davis, *Anomaloscytina* Davis, *Eochiliocycla* Davis, and *Permagra* Ev. Davis has mentioned that *Eochiliocycla* is only tentatively placed in the Scytinopteridae, where it certainly does not belong. *Permoscarta* and *Permagra* are herewith transferred to the Ipsviciidae.

Orthoscytina Till., 1926.

If the number of tegmina found preserved as fossils provide any indication of abundance, then species included in the genus *Orthoscytina* would appear to have been the dominant Auchenorrhyncha of Upper Permian times in Australia. The following diagnostic characters of the genus may now be added to those furnished previously by Tillyard: clavus of the tegmen with two widely separated anal veins, pronotum rectangular, scutellum long, but shorter than the pronotum. These additions have been made possible by the discovery of F 39885, which is illustrated in Fig. 58.

While the generic characters of *Orthoscytina* are well defined and characteristic, the specific ones are otherwise, and it is doubtful whether all the nine species described by Tillyard are justified. This, however, is unimportant when a name is associated merely with a particular specimen and not with a group of individual organisms.

Figures 4–13 are illustrations of the tegmina of the better preserved specimens of *Orthoscytina* which occur in the present collection. Figs. 8 and 11 represent the obverse and reverse of a single tegmen and have been included to indicate the extreme caution which must be observed in drawing conclusions based on minor differences in the venation of fossil wings.



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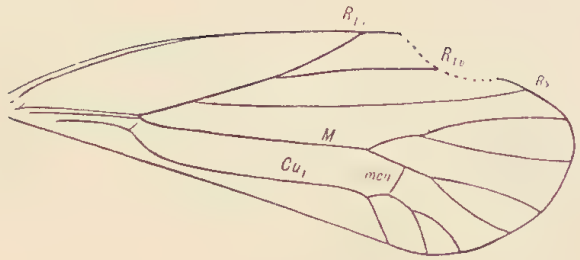

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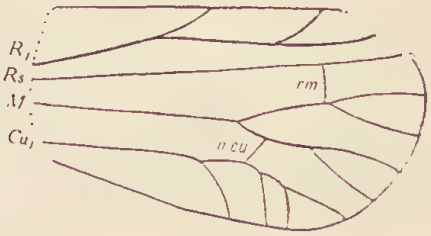

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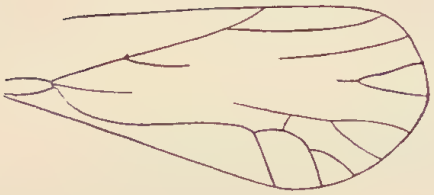

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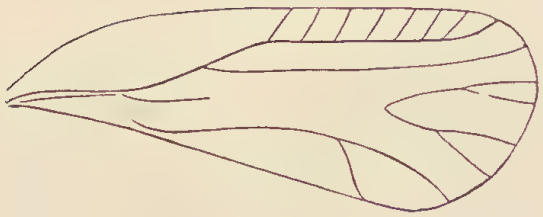

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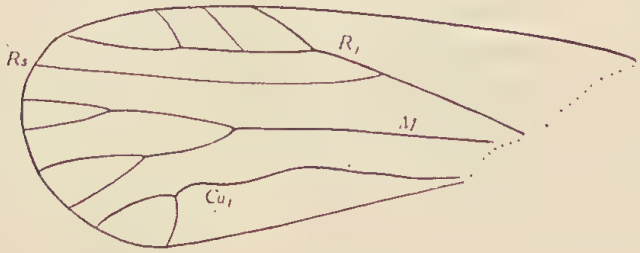

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Orthoscytina spp.

Figs. 4-13.—4, F 40014 (10 mm.). 5, F 39941 (9 mm.). 6, F 40051 (5·8 mm., fragment). 7, F 40019 (6 mm.). 8, F 40023 (7·8 mm.). 9, F 40001 (9 mm.). 10, F 40025 (8·8 mm.). 11, F 39993 (7·8 mm.). 12, F 40090 (9 mm.). 13, F 39988 (7 mm.).

When the ten figures of *Orthoscytina* spp. presented here are compared with Tillyard's illustrations, it is found that exact correspondence cannot be found in a single instance. Figs. 5, 8 and 11 might well be ascribed to *O. belmontensis* Till. and Fig. 12 to *O. tetraneura* Till. In the present instance, it is considered adequate merely to figure the tegmina contained in this collection. When further material is brought to light and a better appreciation becomes possible of the limits of specific differentiation and intra-specific variation, it may be advisable to sink some of Tillyard's species as synonyms or to propose new species. Details of the lengths of the tegmina illustrated are given in the description of the figures.

Homaloscytina Till., 1926.

The same problem of specific differentiation is met with in this genus. Figs. 14–23 are illustrations of the best preserved tegmina representing the several variations which occur in the present collection. Not a single figure is identical with that of the holotype of *H. plana* Till., yet no useful purpose would be served by describing any of the several forms as new species. The differences concern the shape of the apex of the tegmen, the presence, absence and exact position of cross-veins, especially of m-cu, and the length of the branches of M and Cu_1. Variations in details of tegminal venation are not unusual in recent Homoptera. An example occurring in the Jassoidea is illustrated in the Appendix. Details of the specimens of *Homaloscytina* figured are given in the descriptive text. Numbers F 39909 and F 39904 were collected by Mr. Knight at the Pincombe outcrop between Belmont and Warner's Bay.

The tegmen of *H. plana* is clearly that of an insect closely related to various Homoptera of the Russian Permian, such as *Sojaneura aberrans* Mart. (Martynov, 1935*b*). It is not clear why this latter species, among others, was included by its author in the Prosbolidae and not in the Scytinopteridae.

Family IPSVICIIDAE.

Up to the present no representatives of this family have been recorded from Upper Permian strata; they have been known only from the Triassic of Ipswich, Queensland. Five new genera, each with a single species, are described below. In addition, *Permagra*[1] and *Permoscarta* are transferred from the Scytinopteridae to the Ipsviciidae.

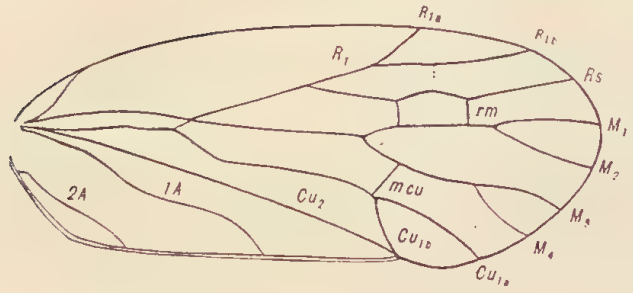
Tillyard (1920) regarded the Ipsviciidae as "early Fulgoroidea", doubtless because of the presence of a Y-vein in the single specimen with a complete clavus. It has already been suggested that the presence of a Y-vein is a character of but limited diagnostic value. It is more probable that the Ipsviciidae were related, if not directly ancestral, to the Cercopidae.

The Upper Permian representatives of the Ipsviciidae described below resemble those from Triassic strata in the shape of the tegmen, which narrows apically, in the indistinctness of the venation towards the apex of the tegmen, and in the basal fusion of M and Cu_1. Of the two specimens occurring with the clavus intact, one has a Y-vein; in the other the anal veins are separate.

Paraknightia, gen. nov.

The pronotum has large and well developed paranotal expansions and is narrowly produced anteriorly. In the tegmen Cu_1, proximally, is parallel to M and to R. The costa is thickened and Sc short and transverse. A nodal line extends from the costal margin to the point where R diverges from M. R is parallel to the costa for the greater part of its length and in the clavus the two anal veins are parallel with each other. The tegmen narrows apically; it is rugose, excepting close to the apex where it is smooth, suggesting that the apex was membranous.

[1] Certain changes in the venational interpretation of *Permagra* are necessary. The vein labelled R_1 is R_{1a}; R_{2+3} is R_{1b}; R_{4+5} is Rs.



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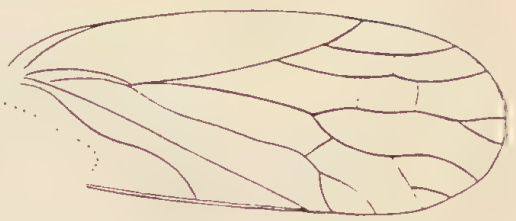

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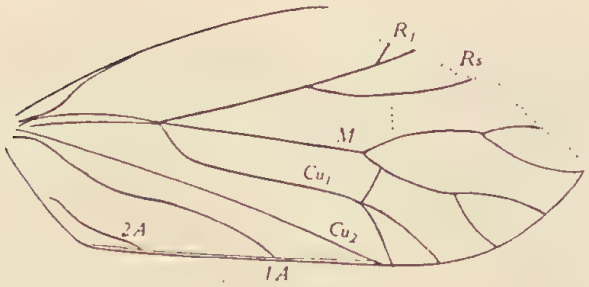

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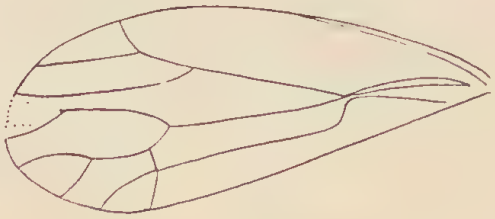

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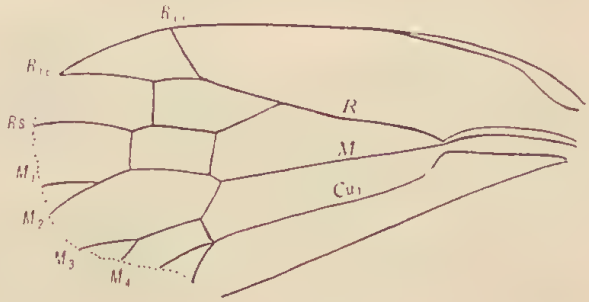


23

Homaloscytina plana.

Figs. 14-23.—14, F 40015 (6 mm.). 15, F 40057 (5·8 mm.). 16, F 40011 (5·8 mm.). 17, F 40012 (5·8 mm.). 18, F 40010 (6 mm.). 19, F 40071 (5·8 mm.). 20, F 39909 (6 mm.). 21, F 39904 (6 mm.). 22, F 40085 (6 mm.). 23, F 40004 (5 mm., fragment).

Paraknightia magnifica, sp. nov. (Genotype.) (Fig. 24.)

Length, from the anterior margin of the pronotum to the tip of the ovipositor, 17 mm. *Length of tegmen*, 12 mm.; greatest width, 4 mm.

Holotype—F 40450, found by Mr. Knight in Upper Permian strata at Lake Macquarie, N.S.W.

This striking fossil is excellently preserved as a ventral impression. The insect is pale brown and the surrounding rock white. The dotted lines in the fork of Cu_1, shown in the figure, represent veins of the hind-wing. In the original description of *Permagra distincta* it was suggested that pronotal paranota might be present, but their recognition was uncertain. In *Paraknightia magnifica* there is no doubt as to their presence. Other interesting structural features are the nodal line and the long ovipositor. The nodal line is not homologous with that occurring in *Prosbole*. Such transverse lines of weakness are of wide occurrence in both fossil and recent Homoptera. With regard to the ovipositor, a few recent Homoptera have unusually long ovipositors; for instance, the Australian Ledrid, *Ledramorpha planirostris* Don. In none are they so long as in *Permoscytina kansasensis* Till. as figured by Carpenter (1939). Whether such a terminal structure as that possessed by *P. kansasensis* functioned as an ovipositor, or, as suggested by Carpenter, as a respiratory tube, must remain uncertain. In the author's opinion the latter explanation is improbable, likewise Carpenter's suggestion that the nymphs of Archescytinids were aquatic.

Fig. 24*a*.

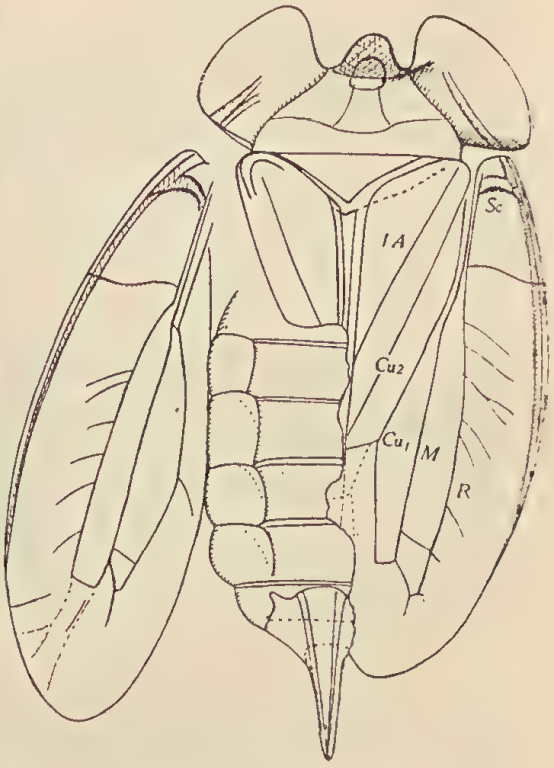


Fig. 24*b*.

Figs. 24*a-b*.—*Paraknightia magnifica*, holotype.

At first sight the inclusion of *P. magnifica* in the Ipsviciidae might appear unwarranted; but, if Fig. 24*b* is compared with Tillyard's illustration of the tegmen of *Ipsvicia jonesi* Till., the genotype of the genus *Ipsvicia* Till., the following resemblances between the two tegmina will be apparent. In both, Rs is parallel to the costa and has numerous transverse costal veinlets; the venation is indistinct ante-apically and the apex of the tegmen narrow. In the position of the nodus of *P. magnifica* Tillyard has

drawn a line in his figure, which does not break the costal border. This line, he indicates, represents Sc, but it is possible that it is a nodal break. The condition in *I. jonesi*, where M and Cu_1 are fused for part of their course, is foreshadowed in *P. magnifica*, where these veins, though distinct, lie closely apposed to one another.

Stanleyana, gen. nov.

The tegmen narrows apically. R is parallel with the costal margin for the greater part of its length, and M and Cu_1 are fused basally. M consists of M_1, M_2 and M_{3+4}. Cu_{1a} and Cu_{1b} are longer than M_1 and M_2. An ambient vein is developed. The clavus is unknown.

Stanleyana pulchra, sp. nov. (Genotype.) (Fig. 25.)

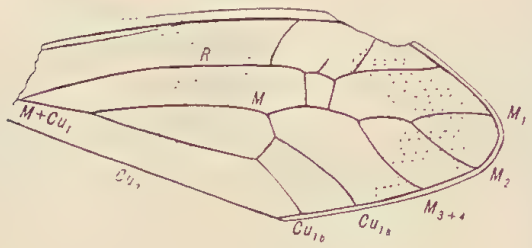
Length of tegmen, 7 mm.; greatest width, 2·8 mm. Colour pattern well developed, the shaded portion, as shown in the figure, being pale brown, the remainder black. The whole tegmen is smooth and was probably coriaceous with the apex membranous.

Holotype tegmen—F 40016, Malcolm Stanley Collection.

S. pulchra represents a later development than *P. magnifica* and shows a further approach to the condition of the tegmina found in Triassic representatives of the Ipsviciidae.

Stenovicia, gen. nov.

The tegmen is narrow and the costa is thickened. R_1 is parallel to the costa for the greater part of its length. M and Cu_1 are fused close to their point of contact with R. M_1 and M_2 are short, and Cu_{1a} is almost twice the length of Cu_{1b}. The clavus is unknown.



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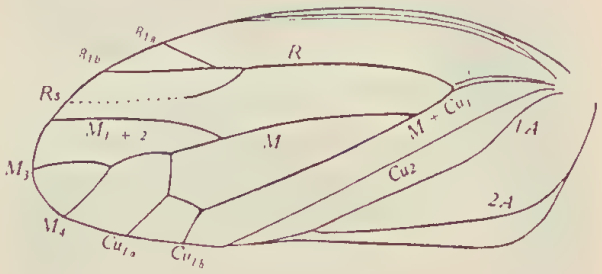

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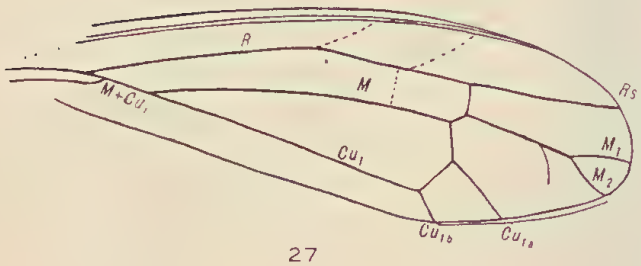

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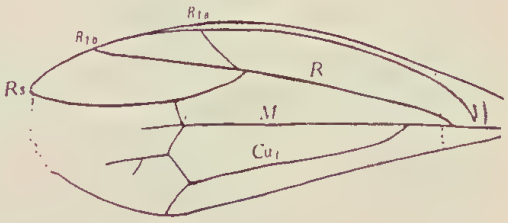

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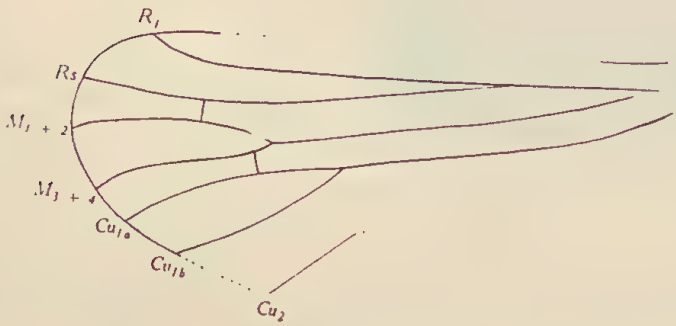

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Figs. 25-29.—25, *Stanleyana pulchra*, holotype tegmen. 26, *Palaeovicia incerta*, holotype tegmen. 27, *Stenovicia angustata*, holotype tegmen. 28, *Permovicia obscura*, holotype tegmen. Fig. 29.—*Anomaloscytina incompleta*, holotype wing.

Stenovicia angustata, sp. nov. (Genotype.) (Fig. 27.)

Length of tegmen, 6 mm.; greatest width, 2 mm. It is uncertain whether an ambient vein is developed or merely an appendix.

Holotype tegmen—F 40008, Malcolm Stanley Collection.

Permovicia, gen. nov.

The tegmen is short and broad. Sc is short, wide and transverse, and R and R_{1b} are more or less parallel to the costal margin. Rs is widely curved, and M and Cu_1 are fused for a short distance basally. The apical terminations of M and Cu_1 are unknown. A nodal break may be present in the position indicated in the figure of the genotype. The clavus is unknown.

Permovicia obscura, sp. nov. (Genotype.) (Fig. 28.)

Length of tegman (fragment), 4·8 mm.; greatest width, 1·6 mm. State of preservation of holotype, poor.

Holotype tegmen—F 40059, Malcolm Stanley Collection.

Palaeovicia, gen. nov.

The tegmen is broad and narrows apically. R and R_{1b} are parallel to the costal margin. Rs is short and straight, and M has three branches, M_{1+2} and M_3 and M_4. M and Cu_1 are fused basally. The clavus is broad and the anal veins form a Y-vein.

Palaeovicia incerta, sp. nov. (Genotype.) (Fig. 26.)

Length of tegmen, 5·7 mm.; greatest width, 2 mm. The whole tegmen is somewhat rugose. A poor impression, especially in the neighbourhood of Rs and M_{1+2}.

Holotype tegmen—F 39999, Malcolm Stanley Collection.

Family SCYTINOPTERIDAE?

Anomaloscytina incompleta, sp. nov. (Fig. 29.)

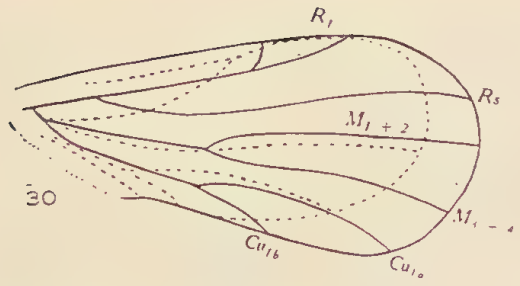
Length of hind-wing (fragment), 10 mm. This wing differs from that of *A. metapteryx* Davis in the greater length of Rs and in having the branches of M shorter than those of Cu_1.

Holotype wing—F 40009, Malcolm Stanley Collection.

Hind-wings of Homoptera, as might be expected, are seldom found in a fossil condition. Even more seldom are they found with their corresponding tegmina. The wing described and figured above may or may not be that of a Scytinopterid. It is of interest to note that up to the present no hind-wings of Permian Homoptera have been found with an ambient vein developed. They thus resemble, in this respect, those of recent Fulgoroidea. Yet the principal characteristics of the tegmina of both the Scytinopteridae and the Ipsviciidae suggest relationships rather with recent Cercopidae and Jassoidea.

Division STERNORRHYNCHA.

It is clear that the small Homoptera described in the families Protopsyllidiidae and Pincombeidae belong neither to the Palaeorrhyncha nor to the Auchenorrhyncha. On the other hand, they possess several characteristics which separate them from recent Sternorrhyncha. Several authors (e.g. Singh Pruthi, 1925; Muir, 1930) have pointed out that the separation of the Homoptera, apart from the Peloridiidae (Coleorrhyncha) into the Auchenorrhyncha and Sternorrhyncha results in an unnatural grouping. However, because of inadequate morphological knowledge, no satisfactory alternative system has yet been proposed, although it is generally acknowledged that the Fulgoroidea need further separation from the rest of the Auchenorrhyncha. Because of the close correspondence evident between the venation of the Protopsyllidiidae and recent Psyllids, it is convenient to regard them both as members of the same division. Whether such action is justified on phylogenetic grounds is uncertain.



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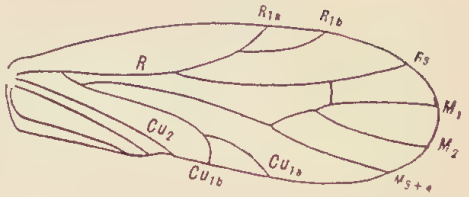

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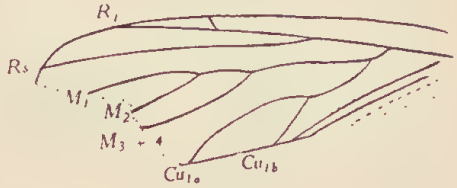

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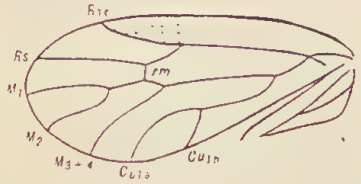

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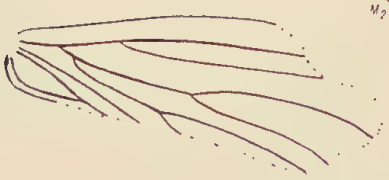
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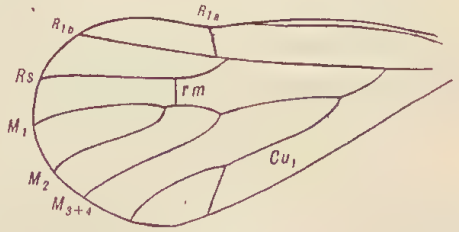

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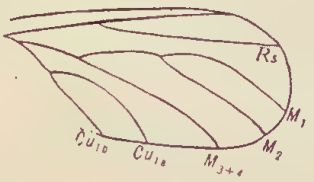

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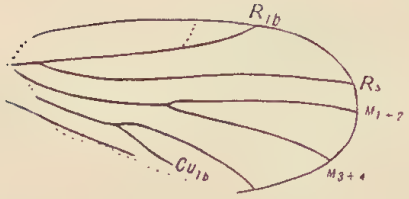

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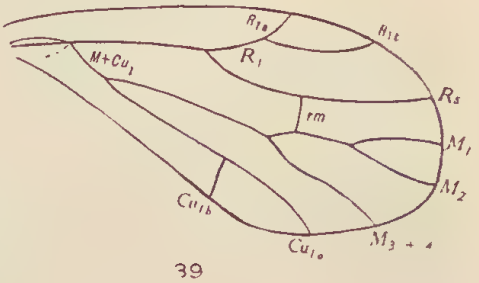

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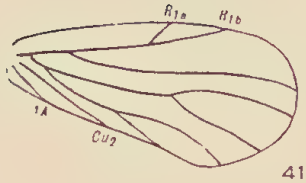

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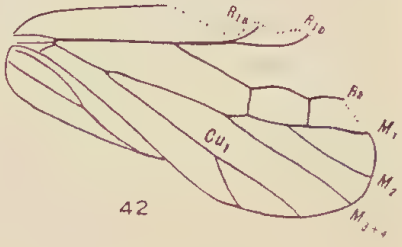

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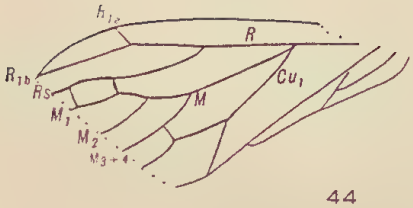

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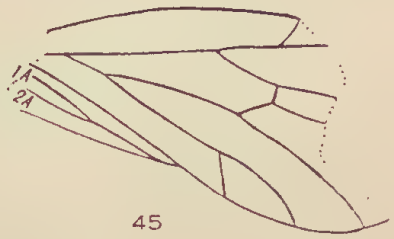

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Family PROTOPSYLLIDIIDAE.

The Protopsyllidiidae comprise small Homoptera from the Upper Permian of New South Wales which resemble recent Psyllidae in size and in the venation of the tegmen, apart from the clavus. They differ from the Psyllidae in the structure of the head and ovipositor. In the head the frons is triangular, the clypeus is joined to the frons and the antennae, which are short, arise from close to the apices of the epistomal suture. In recent Psyllids the frons is so reduced that the median ocellus is all that remains, the clypeus is detached, distinct and of a different shape, and the antennae, which are long, arise from the sides of the head close to the eyes. The ovipositor of the Protopsyllidiidae is of the primitive basic type which is found in recent Auchenorrhyncha, apart from many Fulgoroidea. It consists of paired median valves (presumably three pairs). The ovipositor of recent Psyllids is of a specialized type and does not consist of three pairs of median valves.

With the exception of *Psocopsyllidium media* Davis (Fig. 47), *Eopsyllidium delicatulum* Davis and *Permopsylloides insolita*, gen. et sp. nov. (Fig. 46), all the known tegmina of the Protopsyllidiidae, including those described and figured below, are very similar in general appearance and can be grouped into two clear-cut divisions, differing in the structure of the media. In one group the media has two branches, in the other it has three. The anal veins also show minor differences. Whether, for the purpose of separating the several varieties of tegmina, the erection of numerous genera, instead of two only, is justified, is a debatable question.

Figs. 30–47, with the exception of Fig. 44, represent the best preserved of the various types of tegmina of the Protopsyllidiidae contained in the present collection. A few well-preserved tegmina, identical with some of those figured, also occur. These are not figured.

Protopsyllidium Till., 1926.

This genus contains two species, the genotype *P. australe* Till., and *P. sinuatum* Davis. Davis has drawn attention to the possibility that too little allowance for individual variation and variation in the state of preservation has been made in the past in deciding on interspecific differences between representatives of this family. So far as this genus is concerned, it would appear that due caution has been observed and that two species are certainly justified. The specimen illustrated in Fig. 41 is identified as *P. australe*. It was found by Mr. Knight at Kimble's Hill near Belmont. The tegmina illustrated in Figs. 30, 32, 35 and 38 are all considered as *P. sinuatum*. Details of the index numbers of the specimens figured and of their size (length) are given in the description of the figures.

Permopsyllidium Till., Permothea Till., 1926, Permotheëlla Davis, Permopsyllidops Davis, Clavopsyllidium Davis, 1943.

The association of tegmina contained in fresh collections with species in the above genera will always be a difficult matter. It is suggested that the tegmina reproduced in the following figures belong here: Figs. 31, 34, 39, 40, 43 and 45. Those illustrated in Figs. 33, 36, 37 and 42, while clearly belonging to the same group of genera, are considered to be sufficiently distinct to merit the definition of new genera.

It would seem that all the material of the Protopsyllidiidae originally handled by Tillyard consisted of tegmina lacking a clavus. On this account, except in one instance where 1A was preserved, Tillyard assumed that anal veins were lacking in these insects.

Figs. 30-45.—30, *Protopsyllidium sinuatum* (F 40067: 5 mm.). 31, *Permopsyllidium mitchelli* Till. (F 40069: 3·5 mm.). 32, *Protopsyllidium sinuatum* (F 39997: 3 mm.). 33, *Psyllidiana davisia*, holotype tegmen. 34, *Permopsyllidium affine* (F 40062: 2·8 mm.). 35, *Protopsyllidium sinuatum* (F 39983: 4·5 mm.). 36, *Psyllidella magna*, holotype tegmen. 37, *Protopsyllops minuta*, holotype tegmen. 38, *Protopsyllidium sinuatum* (F 39981: 3 mm.). 39, *Permotheëlla scytinopteroides* (F 39985: 4·8 mm.). 40, *Permopsyllidium mitchelli* (F 40006: 2·4 mm.). 41, *Protopsyllidium australe* (F 40724: 2·8 mm.). 42, *Belpsylla reticulata*, holotype tegmen. 43, *Permopsyllidium mitchelli* (F 40040: 2·6 mm.). 44, *Protopincombea obscura*, holotype tegmen. 45, *Permopsyllidium mitchelli* (F 39901: 4·7 mm.).

Davis was the first to show that the Protopsyllidiidae had a small but well developed clavus with two anal veins. Of necessity a personal bias must operate in determining identifications such as these. For instance, the tegmen reproduced in Fig. 34 has been associated with *Permopsyllidium affine* Till., although it might equally well have been identified as that of *Permotheëlla scytinopteroides* Davis. The specimen (F 39901) illustrated in Fig. 45 was found by Mr. Knight at the Pincombe outcrop between Belmont and Warner's Bay.

Psyllidiana, gen. nov.

The tegmen is narrow, and R_1 and Rs are both straight. M has three branches, M_1, M_2 and M_{3+4}. Cu_{1a} is longer than the basal portion of Cu_1. The clavus of the holotype of the genotype is incomplete; but it is probable that the anal veins are separate for their entire length.

Psyllidiana davisia, sp. nov. (Genotype.) (Fig. 33.)

Length of tegmen, 3 mm. A poor impression suggesting a delicate tegmen.

Holotype tegmen—F 40711, collected by Mr. Knight at the Pincombe outcrop between Belmont and Warner's Bay.

Psyllidella, gen. nov.

The tegmen is broad and the costal margin is thickened and sinuate. R_1 is straight, and Rs leaves R at a point in line with the first bifurcation of M. The clavus is unknown.

Psyllidella magna, sp. nov. (Genotype.) (Fig. 36.)

Length of tegmen, 5 mm.; greatest width, 2 mm. A pale yellowish-brown negative impression on white coarsely grained rock.

Holotype tegmen—F 40043, Malcolm Stanley Collection.

P. magna resembles *Psocoscytina bifida* Davis in size and superficial appearance, although the latter has been placed by its author in the Scytinopteridae. It differs in having Rs single and in having M_3 and M_4 fused together and not M_1 and M_2.

Protopsyllops, gen. nov.

The tegmen is short and broad. R_1 lies close to the costal margin, Rs is long, and the first branching of M occurs close to the junction of M and Cu_1. All the three branches of M are long, and Cu_{1b} is parallel to Cu_{1a}.

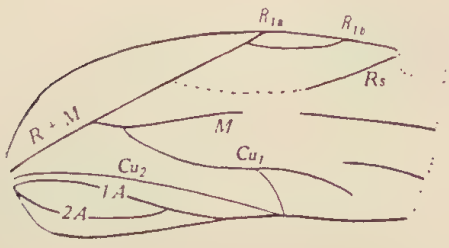
Protopsyllops minuta, sp. nov. (Genotype.) (Fig. 37.)

Length of tegmen, 3·1 mm.; greatest width, 1·1 mm.

Holotype tegmen—F 40005, Malcolm Stanley Collection.

Belpsylla, gen. nov.

The tegmen is long and apically broad. R_{1a} and R_{1b} curve towards the costa. There are two cross-veins between R and M, all three branches of M are straight, and Cu_1 is narrowly forked. The clavus has a well-developed Y-vein.



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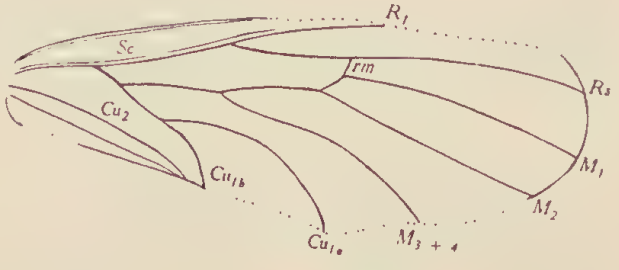

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Figs. 46, 47.—46, *Permopsylloides insolita*, holotype tegmen. 47, *Psocopsyllidium media* (F 39953: 4·7 mm.).

Belpsylla reticulata, sp. nov. (Genotype.) (Fig. 42.)

Length of tegmen, 3·8 mm.

Holotype tegmen—F 39992, Malcolm Stanley Collection.

The tegmina illustrated in Figs. 46 and 47 are quite distinct from the remainder of the Protopsyllidiidae, the former on account of its wide costal space and short straight radius, the latter on account of its size, shape and general appearance. Fig. 47 is the tegmen of *Psocopsyllidium media*. In the specimen figured, R is convex, and there is a depression alongside this vein which has been indicated in the figure and labelled Sc. Whether it actually represents Sc is uncertain.

Permopsylloides, gen. nov.

The tegmen is of even width for its entire length. The costal space is wide, and R_{1a} meets the costal border slightly beyond its centre and Rs is curved towards the costa. The number of branches of M is unknown. The clavus is wide and long, and the anal veins form a Y-vein.

Permopsylloides insolita, sp. nov. (Genotype.) (Fig. 46.)

Length of tegmen, 4 mm.; greatest width, 1·5 mm. A poor impression.

Holotype tegmen—F 40727, found by Mr. Knight at Kimble's Hill, near Belmont.

Family **PINCOMBEIDAE.**

The genera *Pincombea* Till. and *Eupincombea* Davis have previously been placed in this family. The tegmen illustrated in Fig. 44 is herewith added because it resembles *Pincombea mirabilis* Till. in having M and Cu_1 arising separately from the same point on R without a basal common stem. It is, however, doubtful whether adequate justification exists for the separation of this family from the Protopsyllidiidae.

Protopincombea, gen. nov.

The tegmen is broad and the clavus short and narrow. R is parallel with the costal margin and there are two cross-veins between Rs and M and one between M and Cu_1. M has three branches, M_1, M_2 and M_{3+4}. M and Cu_1 arise from the same point on R, but lack a common stem. The anal veins form a Y-vein.

Protopincombea obscura, sp. nov. (Genotype.) (Fig. 44.)

Length of tegmen (fragment), 4·2 mm.; greatest width, 2 mm. As well as the tegmen, the thorax and abdomen of the holotype are preserved. Their total length is 3·5 mm., and that of the abdomen alone, 2 mm.

Holotype tegmen—F 40075, Malcolm Stanley Collection.

Attention is drawn to the resemblance which exists between the tegmen of *P. obscura* and the hind-wing of *Sojanoscytina (?) latipennis* Mart. (1933). It is suggested that the latter wing is actually a tegmen of an insect belonging to the Pincombeidae or Protopsyllidiidae, and not part of an Archescytinid as suggested by Martynov, even though Rs has two branches. Carpenter (1939) is also of the opinion that *Sojanoscytina (?) latipennis* is not an Archescytinid.

Head-structure.

In an earlier paper (Evans, 1943) the head-structure of two Upper Permian Homoptera was described and figured. One of these, *Permagra distinca* Ev., belonged to the Auchenorrhyncha. The other, *Permocephalus knighti*, which was originally placed in the Palaeorrhyncha, has, in an earlier section of this paper, been transferred to the Sternorrhyncha.

Five moderately well preserved heads occur in the present collection. These are illustrated in Figs. 48–52. A new genus and species are necessary for the head reproduced in Fig. 48; the remainder are considered as specimens of *P. knighti*.

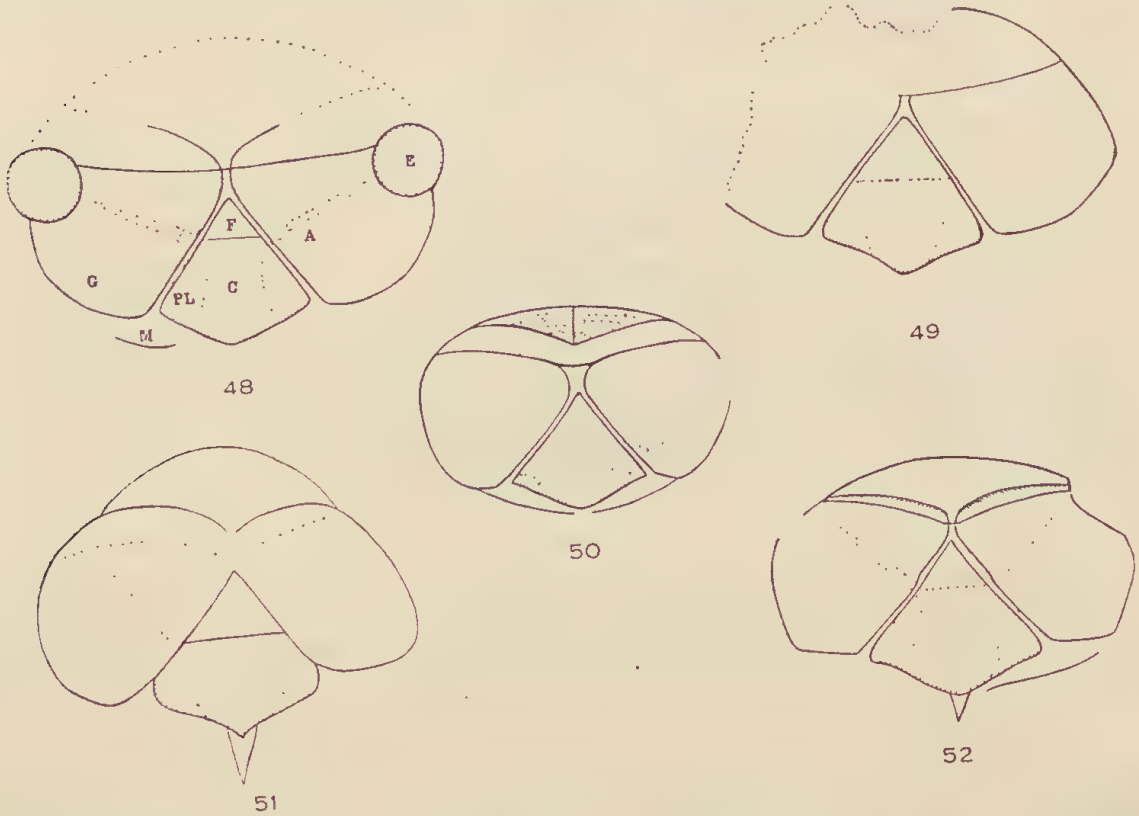
In Evans (1943) the statement was made that *P. knighti* lacked traces of clypeal sutures. By "clypeal sutures" is understood the sutures which separate the lora,

paraclypeal lobes or mandibular plates, from the clypeus proper. In all the heads now figured, faint indications of such sutures occur. They are indicated in the figures by dotted lines. A small triangular frons lies posterior to the clypeus in every specimen.

Ferris in a recent paper (1943) gives a figure (Fig. 1) of a generalized insect head which, in some respects, bears a striking resemblance to Fig. 48. The differences evident between the two heads would appear to be bridged by Ferris's diagram (Fig. 2D). If the interpretation given by Ferris is correct, the wide V-shaped suture towards the back of the head in Fig. 48 is the premandibular suture and the line joining the eyes a secondary ridge of no structural significance. The inverted V-suture is made up, according to Ferris, of the postfrontal + tentorial sutures, while the suture referred to in a former paragraph as the clypeal suture must together with the transverse epistomal suture make up Ferris's clypeo-frontal suture. It is, however, more probable that the paraclypeal lobes are part of the clypeus and that the clypeo-frontal suture is restricted to the transverse suture which lies between the antennal bases. Unfortunately, the fossils do not throw any light on the principal problem of the Homopterous head, and a satisfactory explanation is still needed to show how the paraclypeal lobes come to continue under the ante-clypeus and to form medially the ventral surface of the sucking-pump.

Ocelli are not preserved in the fossils, but a median ocellus, if present, would lie on the triangular frons, anterior to the post-frontal suture. Both Ferris and Cook (1943) are of the opinion that the inverted Y-suture of the heads of Corydalid larvae is the clypeo-frontal suture, although the corresponding suture in the heads of adult insects lies posterior to the median ocellus and anterior to the paired ocelli!

If the heads illustrated in Figs. 48–52 are compared with those of a recent Psyllid, correspondence will be found between the wide genae of the two types, which in neither instance are fused facially with the maxillary plates. The small triangular frons is lost in recent representatives, only the median ocellus remaining to indicate its position. The antennae in most, though not in all, recent Psyllids are long, and in all consist of ten segments. Upper Permian Psyllids had short antennae containing an unkown



Figs. 48-52.—48, *Permocapitus globulus*, holotype head, in facial aspect. F., frons; A., antenna; G., gena; C., clypeus; PL., paraclypeal lobe; M., maxillary plate (?). 49-52, *Permocephalus knighti*, head in facial aspect.

number of segments. Further, the position of the antennal bases has moved from close to the apices of the epistomal suture to the neighbourhood of the eyes.

Permocapitus, gen. nov.

The head is oval in shape, the eyes globular and the frons small. A transverse ridge lies between the eyes, and a suture (the premandibular suture?) separates a wide V-shaped area at the back of the head from the rest of the face.

Permocapitus globulus, sp. nov. (Genotype.) (Fig. 48.)

Length (of whole insect), 5 mm. Width of head, 1·2 mm. A complete median ovipositor is present in the abdomen. No trace of wings is retained in the holotype.

Holotype—F 40078, Malcolm Stanley Collection.

Permocephalus knighti. (Figs. 49–52.)

For convenience, the remaining heads are identified with this species. Particulars of the various specimens follow:

Fig. 49 (F 39967). Width of head, 1·4 mm. Part of the abdomen and legs are also preserved and a wing fragment. The latter suggests affinities with *Permotheëlla scytinopteroides.*

Fig. 50 (F 39944). Width of head, 1·2 mm. The posterior quarter of the head, divided medially by the coronal suture and shaded in the figure, is almost certainly part of the crown; the rest of the head consists of the face. No trace of wings is preserved.

Fig. 51 (F 40449). Width of head, 1·1 mm. Seven abdominal segments, having a total length of 2·2 mm., are also preserved, but no trace of wings. This specimen was found by Mr. Knight at Lake Macquarie.

Fig. 52 (F 39945). Width of head, 1·2 mm. Length of whole insect, 5·6 mm. The abdomen of this specimen is illustrated in Fig. 57.

Fragments.

A well preserved nymph and various fragments are illustrated in Figs. 53–59. With the exception of Fig. 58 (*Orthoscytina* sp.), none of the specimens is named, although the practice is often observed of naming even less complete specimens of fossil insects.

Fig. 53 (F 40448). Length of whole insect 9 mm.; width, at widest point, 4 mm. Part of the crown of the head and the pronotum and scutellum are well preserved. A coronal suture is discernible, and the lateral flanges on the pronotum suggest possible relationship with the Ipsviciidae. The proximal costal area of each tegmen is distinct, but no veins are visible. Found by Mr. Knight at Lake Macquarie.

Fig. 54 (F 40083). A splendidly preserved impression of a nymph, 1·5 mm. long and 0·8 mm. wide, which may well belong to the Protopsyllidiidae. It is remarkable to find such a minute insect so well preserved.

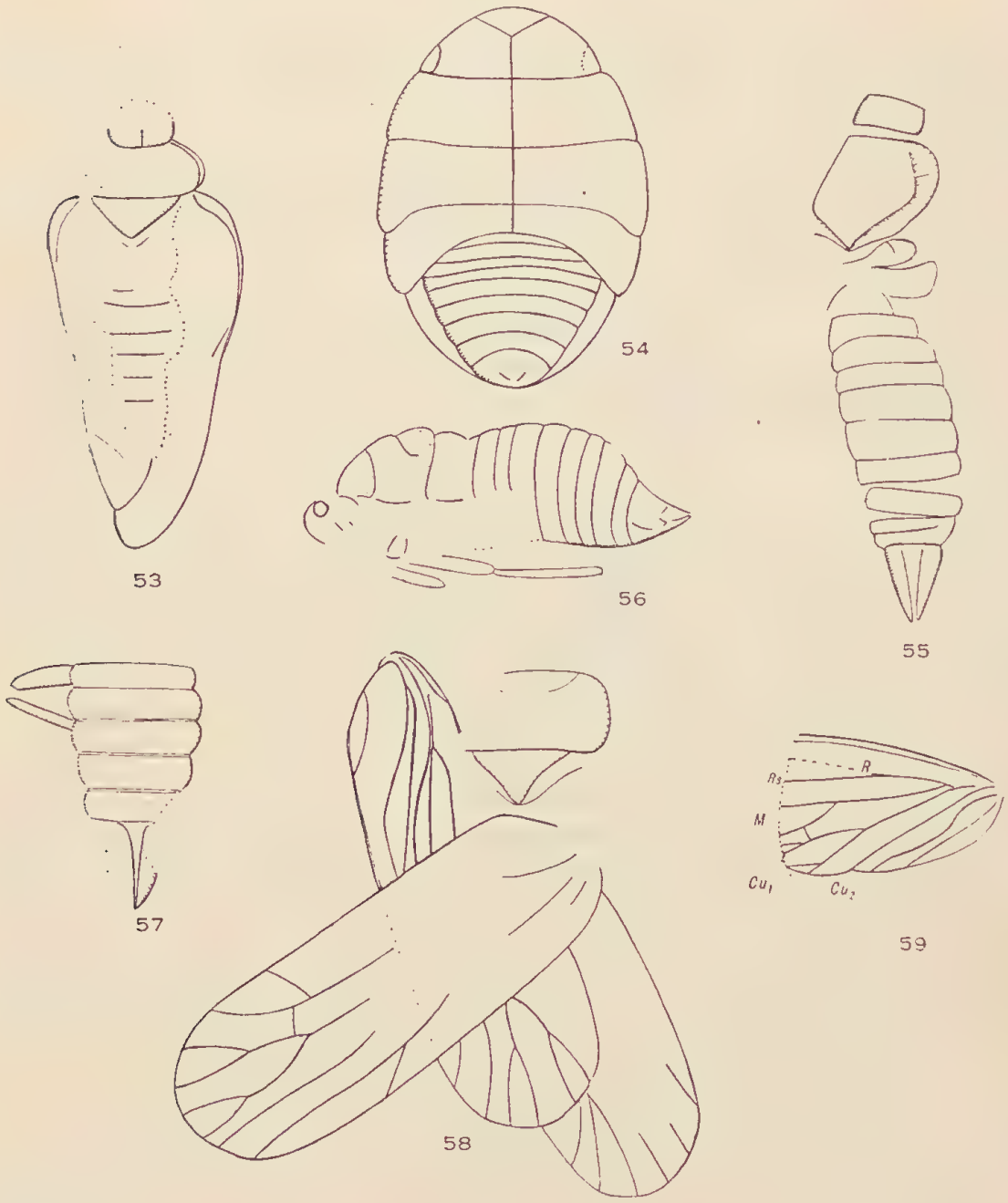
Fig. 55 (F 40077). Length of specimen, 6 mm. It is possible that the small rectangular pronotum is neither complete nor in position and the wide mesonotum may have been partially concealed by the pronotum. The affinities of this specimen are quite unknown.

Fig. 56 (F 39951). A good impression of a small Homopteron in lateral aspect. The process suggesting a labium is believed to be part of a leg, as reason exists for believing that the labia of Permian Sternorrhyncha were short. The genital segments, in outline, are reminiscent of those of recent female Psyllids.

Fig. 57 (F 39945). The head of this specimen is illustrated in Fig. 52. The figure of the abdomen is reproduced to illustrate the type of ovipositor possessed by Permian Sternorrhyncha.

Fig. 58 (F 39885). This is the first specimen of an *Orthoscytina* to be found with the clavus intact. The width of the hind margin of the pronotum is 3 mm. and the length of each tegmen 9 mm. The venation of only a small part of the hind-wing is distinguishable. Found by Mr. Knight at the Pincombe outcrop between Belmont and Warner's Bay.

Fig. 59 (F 39977). This interesting fragment may be part of the tegmen of an Archescytinid. The length of the fragment is 4·2 mm. and its greatest width 2 mm.



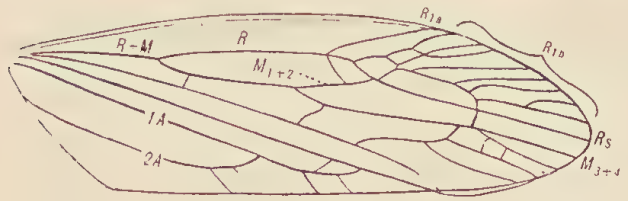
Figs. 53-59.—54, Nymph (Protopsyllidiidae). 58, *Orthoscytina* sp., part of thorax, tegmina and wing. 53, 55, 56, 57, 59, un-named fragments; for description see text.

Appendix.

The tegmina illustrated in Figs. 60–64 are those of four recent Jassoids and a recent Cercopid. They are presented here for three purposes. The first purpose is to give some idea of the wide variation in minor details of venation which may occur in recent insects belonging to a single species. The second is to show how, even within the same family or super-family, marked differences in major venational features may occur. The third is to give an example of how fossil wings may be used to assist in the interpretation of the venation of the wings of recent insects.

Figs. 60 and 61 represent the tegmina of a female and male respectively of *Stenocotis depressa* Walk. (Stenocotidae, Jassoidea). The two tegmina are drawn to the same scale, so that their difference in size as well as in venational details is evident.

Figs. 62 and 63 represent the tegmina of *Macroceps fasciatus* Sign. (Thymbridae, Jassoidea) and *Cornutipo scalpellum* Ev. (Eurymelidae, Jassoidea) respectively. Differences to note in comparing the four Jassoid tegmina are the presence of a Y-vein in the clavus of *Stenocotis* and the separate anal veins of *Macroceps* and *Cornutipo*. *Stenocotis* and *Macroceps* have Rs well developed; in *Cornutipo* R is unbranched. In *Stenocotis* and *Macroceps*, M_{1+2} is reduced to a cross-vein; in *Cornutipo* it is fully developed.



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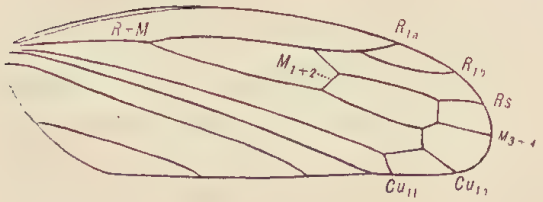

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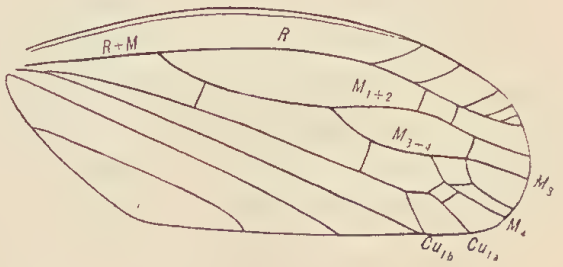

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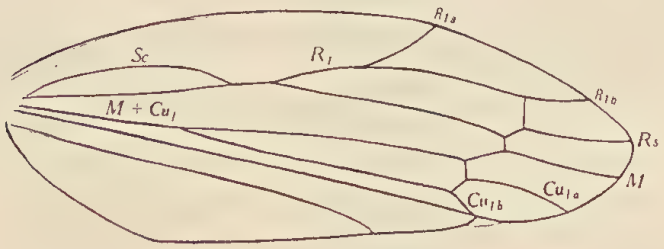

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Figs. 60-64.—60, *Stenocotis depressa*, tegmen (female). 61, *S. depressa*, tegmen (male). 62, *Macroceps fasciatus*, tegmen. 63, *Cornutipo scalpellum*, tegmen. 64, *Philagra parva*, tegmen.

Metcalf (1913, 1917) has investigated the venation and preceding tracheation of the Jassoidea and Cercopidae. With regard to the former he has advanced the opinion that the two branches of the typical Jassoid radius represent R_{2+3} and R_{4+5}. The three branches of the Cercopid radius he considered as R_1, R_{2+3} and R_{4+5}.

In an earlier paper (Evans, 1939) Metcalf's interpretation was followed, so far as the Jassoidea are concerned, although Tillyard (1926*a*) had previously drawn attention to the incorrectness of such an interpretation.

As a result of the study of the fossils contained in the present collection, Tillyard's interpretation is accepted, and in the figures of the four Jassoid tegmina and the Cercopid tegmen (Fig. 64, *Philagra parva* Don.) the veins have been labelled in accordance with this interpretation. Thus the hypothetical tegmen of the common ancestor of recent Jassoidea as presented in Evans (1939), Pl. v. fig. 2, becomes identical with Carpenter's (1933) reconstruction of the common ancestor of Lower Permian Homoptera.

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THE COROID AND KNAPPED STONE IMPLEMENTS OF THE BATHURST DISTRICT.

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(Figures 1–48.)

In 1941 the late Mr. A. E. Ivatt presented to the Australian Museum a collection of one thousand eight hundred stone implements from New South Wales sites, including a splendid series that he had gathered in the Bathurst district during a long occupation of Glanmire Station, which is about five miles from the town. In this paper, the fourth of a series analysing New South Wales industries, the trimmed uniface pebble, coroid, and knapped implements are described.

Bathurst is situated on the southern tableland, an area of undulating pastoral and farming country. The implements were collected on the grassed and ploughed fields, and beside the numerous creeks that flow through Glanmire and neighbouring properties. They are from a large numer of localities, too numerous to mention here, scattered throughout the district.

Materials.

The predominant materials are a quartzose rock, fine to coarse grained, and chert, both varying in colour from light to dark grey. Occasional pieces of flint and other materials have also been found.

Technique.

The plain and faceted butt techniques of knapping are both represented, and the latter appears to have been employed mainly for the production of blades. On the cores the striking-platforms were prepared by the usual methods, comprising the knapping of one or more flakes, the use of a natural crust surface, or a cleavage face on a block; sometimes flake-scars served as additional platforms. The knapping face is at an angle varying from 70° to 90°, is sometimes as low as 65°, and commonly in the vicinity of 80° to the stiking-platform. Prismatic cores displaying convergent flaking predominate, and a minority of cores bear irregular parallel knapping.

During an examination of the cores, Mr. H. V. V. Noone selected a number of specimens upon which he has supplied the following note: "Among pieces of nuclear form from the Bathurst district are fifteen blocks and flakes which are worthy of special attention as they may have served for the production of small blades, in fact, as a kind of secondary nuclei. On these pieces (Fig. 3) is found a striking-platform (some specimens show one at each end) by means of which small blades have been detached from one or both margins. Most of these blades would be of triangular section, similar to primary burin spalls, so that in their production it is possible that advantage was taken of the more or less long straight edges of the side margins of the blocks or flakes, and they were utilized as fracture guides. Such a method would obviate the preparing of a suitable knapping face on an ordinary nucleus, or the formation thereon by trimming of a guiding ridge such as was sometimes employed in producing the *bondi* point, and would therefore be an ingenious labour-saving device in the obtaining of the required narrow bladelet. Something of this kind has been noticed in the Bandarawelian culture of Ceylon, whilst flakes and blocks have been found in the Woakwine industry of South Australia which likewise appear to have been used for the production of small blades. Some of these particular pieces resemble the *nucleiform* (prismatic or polyhedric) form of burinate tool, whilst others like the *double-scaled* burinate could be used as a kind of groover."

Most of the knapped pieces are squat, thick flakes, the outstanding type among which is the *arapia* (Figs. 12–22). The latter is rectangular, semi-discoidal and discoidal in shape, and is usually thick with a steep-faced working edge. The bulb of percussion is not prominent or is lacking on many of the implements because some of the materials used have fractured along flat cleavage surfaces. The inner platform angle is from 100° to 125°, is sometimes as low as 95° and as high as 135°. Trimming

Figs. 1-11.—1, *Worimi*. 2, Core with a faceted striking platform at both ends. 3, Secondary nuclei. 4, Biface discoid core implement. 5-8, Nucleiform burinates. 9-10, Bevel-scaled burinates. 11, Concave-scaled burinate. (Two-thirds natural size.)

and retouch are similar in character to such work on the south coast of New South Wales (McCarthy, 1943, 130), and at Singleton (McCarthy and Davidson, 1943). Although blades are uncommon, there is one type up to 8 cm. long with a faceted butt and untrimmed edges. Punch-type flake fabricators are well represented.

Artefacts.

The 593 implements comprise 88 cores, 4 cores used as implements, 48 coroids, 2 biface coroids, 6 uniface pebble implements, 28 blocks, 1 *worimi*, 2 cleavers, 33 *bondi* points, 5 geometrical microliths, and 439 normal flake and blade implements (including 14 *elouera*). They were collected indiscriminately over a long period, and represent a fair sample of the local industry; their analysis is given for comparison with those of the south coast and Singleton sites. It will be noted that the side and end, double side, double side and end, semi-discoidal and discoidal scrapers in the normal flake and blade series are more highly represented at Bathurst than in the above two areas. Other points of interest are the low numbers of uniface pebble implements, *bondi* points, geometrical microliths, and *elouera*. These differences might be explained by the fact that Bathurst is in the vicinity of the western boundary of the *bondi* point culture and the eastern boundary of the western cultures of which the *arapia* is a feature. The importance of coroids and blocks, and of concave, nosed and end scrapers is noteworthy. Knives are well represented, but cleavers are as scarce as elsewhere.

I. Coroids	
Cores (87)	
One striking platform	27
Two striking-platforms at opposite ends	43
Two or more platforms at angles to one another	15
Conical	1
Discoid	1
Cores used as implements (4)	
Coroid implements (48)	
Straight to convex edges	15
Concave	7
Nosed	5
Burinate (nucleiform)	19
Biface	2
Uniface pebble implements (6)	
End	—
Lateral	1
End and lateral	3
Uniface	1
Split-pebble	1
II. Blocks (29)	
Straight to convex	11
Concave	5
Nosed	12
Worimi	1
III. Cleavers (2)	
IV. Normal flake and blade implements (439)	
Elouera	
type 1	5
type 2	3
type 3	6
Utilized	4
Scrapers	
Side	77
Side and end	19
Double side	31
Double side and end	33
Semi-discoidal	15
Discoidal	21
End	
distal	27
butt	16
double	1
Concave	
lateral, lateral and end	36
distal end	13
butt end	10
Nosed	33
Piercers	—
Burinate	
spalled	—
scaled	4
Knives	64
Serrated	1
Fabricators	
general	4
punch-type	16
V. *Bondi* points (33)	
Conformation	
left	23
right	10
Trimmed on single edge	
(*a*) distal end and plain butt	6
(*b*) distal end and butt	1
(*c*) distal end and faceted butt	4
(*d*) completely	9
Trimmed on two edges of thick margin	
(*e*) distal end and plain butt	—
(*f*) distal end and butt	2
(*g*) distal end and faceted butt	3
(*h*) completely	8
Butt	
plain	6
faceted	7
trimmed	20
Thin margin use	
knife	8
scraper	5
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equilateral	—
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Normal flake and blade (71)	
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Side and end	3
Double side	5
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End	
distal	5
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I. Coroids.

Cores.

Prismatic cores with two striking-platforms at opposite ends are in the majority, but those with one striking-platform are well represented. The angled platform group is in the minority. There is only one conical core, 6·5 cm. in diameter, but it is not of *horse-hoof* type. The semi-discoid core, 7 cm. in diameter, has a step-chipped concave edge at one end. Single platform pebble cores and tortoise cores are absent, but there are several globular examples in the irregular group. A large number of the cores are prismatic nuclei. Among the nuclei is a flattened, irregular biface discoid type (Fig. 4), sometimes bearing two opposed striking-platforms on the same or on opposite knapping faces, and a third platform, for which a flake-scar has been utilized, at right angles to the other two; some with four platforms have two series of narrow flake-scars at right angles to each other on both surfaces. These nuclei are skilfully worked to produce narrow bladelets until they are less than 1 cm. in thickness. There are four specimens in the collection: one has two, two have three, and one has four striking-platforms, which are faceted on three specimens. They are 3–4 cm. long. These nuclei occur on the south coast of New South Wales and at Singleton (McCarthy and Davidson, 1943, p. 213, fig. 77).

Two of the cores have two opposed faceted striking-platforms (Fig. 2). Cores with two opposed striking-platforms often display alternate flaking.

Cores used as implements.—The four specimens are irregular in shape, and all have concave working edges 2–3·5 cm. wide. The largest example is of *horse-hoof* type, with a crust striking-platform, its margin is trimmed all round and bears two concaves with battered edges due to fabricator use. 5–8 cm. long.

Coroid implements.

The implements described under this heading have a crust lower surface, but they form a distinct series quite different from the uniface pebble implements, which are also trimmed coroids.

Crown.—Those with straight to convex working edges comprise three end, three side and end, three double side and end, one semi-discoid, and one discoid (Fig. 20). The largest specimen is rounded, with a semi-discoidal trimmed edge, is flat on both surfaces, and is 4 cm. thick. Two of the discoids are rectangular with rounded corners, and one is round; one is 6 cm. long with a well used fabricator margin, curved upwards and 3 cm. long, at one end. 5–9·5 cm. long.

Those with concaves, which are 2–2·5 cm. wide, comprise two semi-discoids and two discoids 5–6 cm. long.

In the nosed series is a discoid, and one with a tongue-shaped trimmed margin bearing rounded noses. One is trimmed half-way along its margin from one surface and half-way from the other surface, and it bears a small triangular nose at one end. One has a triangular nose on both lateral margins. A ridge on the lower surface of one is polished from end to end as though from use. 4·5–8 cm. long.

Keeled.—A small series, comprising a side, double-side, double side and end, semi-discoid, and discoid examples. Two bear narrow concaves and one rounded noses on both lateral margins. 5·5–9 cm. long.

Uniface pebble implements.

One 9 cm. long has a trimmed semi-discoid lateral margin which is steep-faced and notched. One 13 cm. long is oval in shape, trimmed on one lateral margin and end

back to the middle of the upper surface, and it has a striking-platform on one end from which two flakes have been knapped. One 16 cm. long is irregular oval in shape, has a trimmed steep-faced edge along part of both lateral margins and on the rounded end.

There are three specimens trimmed all over one surface, but none of them is *sumatra*-type. Two have a central patch of crust on the upper surface, and trimmed working edges on various parts of their margins; they are 8 and 10 cm. long. One 13 cm. long is a semi-discoid trimmed all over one surface, and bears two concave working edges 2·5 and 4 cm. wide.

The split-pebble implement has a well trimmed lateral margin forming a long shallow concave edge, and the ridges on its upper surface are polished as though from use.

The poor series of uniface pebble implements, and especially the absence of the *sumatra*-type, indicate that it is not an important cultural factor in this area.

Biface discoids.—Two oval specimens 6 and 7 cm. long. They are not trimmed continuously round their margins.

II. Blocks.

Crown.—Those with straight to convex working edges comprise four side, one side and end which has the two trimmed margins meeting at a right angle, one discoid, and two oval or tongue-shaped with plain butt, one of which bears a notched margin (Fig. 16). Ridges on the inner face of three specimens are polished as though from use. 3·5–8 cm. long.

The concaves comprise one semi-discoid, and one tongue-shaped with untrimmed butt. The concaves are all 2 cm. wide. 7–8 cm. long.

There are six specimens bearing noses, comprising one side, four semi-discoids, one tongue-shaped with untrimmed butt (Fig. 17), and one discoid (Fig. 21), which is trimmed all round. Four bear one rounded nose from 0·5 long by 1 cm. wide to 1·5 by 2·5 cm. The discoid is 5 cm. long, bears three rounded noses bounded and separated by five concaves 1–2 cm. wide. 5–9·5 cm. long.

Keeled.—The trimmed margin on one is short and straight, and on the other is semi-discoidal. 4·5–5·5 cm. long.

Two bear two, and one three, concaves which are 2·3 cm. wide. They comprise a side, a pointed double side (Fig. 18), and a semi-discoid. 5–8 cm. long.

Five specimens bear noses which are all small, three rounded and two triangular. One has two triangular and one rounded noses separated by concaves on the one margin. The noses are up to 0·75 cm. long. Four specimens have side, and one a semi-discoidal, trimmed margins. 4·5–6 cm. long.

Worimi.—The one specimen (Fig. 1) is a splendid example, to all intents and purposes a very large *elouera*. It has three rounded noses, one 2 cm. and the others 1 cm. wide at the base, separated and bounded by four concaves; its butt end is notched along the outer edge, and its chord is smoothed and polished as though from use, but it is not ground. Half of one surface from the chord inwards is pebble crust. It is made of brown chert. 10 cm. long, 6 cm. wide, 5 cm. thick.

Burinate (Figs. 5–8).—There are nineteen specimens of the type classified by Noone (1934, 84) as spalled, A, VI, nucleiform, with vertical spalls from margin and face and a horizontal platform. They form the finest series of burinates of one type yet recorded from New South Wales. They are all elongate. Ten of the burinate edges are formed by one spall, three of which have run the full length of the face and seven are foreshortened and end in a ledge; four are formed by from two to four spalls. Four have a burinate edge at each end of the same margin, and one (Fig. 7) at each end on opposite margins, thus making five doubles. 3–6 cm. long. There are two utilized spalled burinates, 2–3 cm. long.

III. Cleavers.

One is trimmed on one lateral margin and end, and one on both lateral margins and end. Both bear concaves from 2–3 cm. wide. 8 and 12 cm. long.

IV. Normal Flake and Blade Implements.

Cutting and scraping edges.

Elouera.—The three varieties of McCarthy (1943, 139–40, figs. 17–19) are evenly represented in the small series of *elouera*. A high proportion, nine out of fourteen, bear scraper trimming on the chord (Fig. 23), two of which are notched; the remainder bear evidence of use as knives on this margin. Several bear concaves on the thick margin, but none have a nose. Two in variety ii are trimmed on the thick margin at the distal end only. One unusual flat blade in variety iii is trimmed on both ends only, and has a knife-edge on the chord. One has a faceted butt. Two are less than 3 cm., the balance up to 5 cm. long.

Utilized.—All examples have both cutting and scraping edges on various parts of their margins. Two have faceted butts. One is a slender blade 8 cm. long, with one well-used saw-like lateral margin and end and a faceted butt. Four are less than 3 cm., the balance up to 8 cm. long.

Scraping edge.

Side.—Twenty are blades, but there are no abrupt trimmed bladelets among them. Two are segments with crust back. Three are trimmed on the inner face from the outer face, and nine have faceted butts. Twenty are less than 3 cm., the balance up to 9 cm. long.

Side and end.—Five are blades. The trimmed lateral margin and end meet at a sharp angle or in a rounded curve and form a corner which could have served as a nose. None has a faceted butt. Three are thick rectangular *arapia* (Fig. 15), and on one of them the ridges on its inner face are polished as though from use. Two are quartz thumbnail scrapers, 2·75 cm. long. Three are less than 3 cm., the balance up to 7 cm. long.

Double side.—Eighteen are blades. Eight of them, from 3·5 to 4·5 cm. long, are trimmed from the inner face on one margin, and from the outer face on the other margin, and one (Fig. 24) is trimmed from the outer face on both margins; attention has been drawn to this reverse method of using a blade (McCarthy, 1943, 142) on the south coast of New South Wales, and at Singleton (McCarthy and Davidson, 1943, p. 217, fig. 20), but no reason for it is known. One blade is quartz. Two are pointed. One is abrupt trimmed on both margins, but is only portion of a narrow blade. Two have faceted butts. They are all flat and thin except one, which is a thick *arapia*. Five are less than 3 cm., the balance up to 6 cm. long.

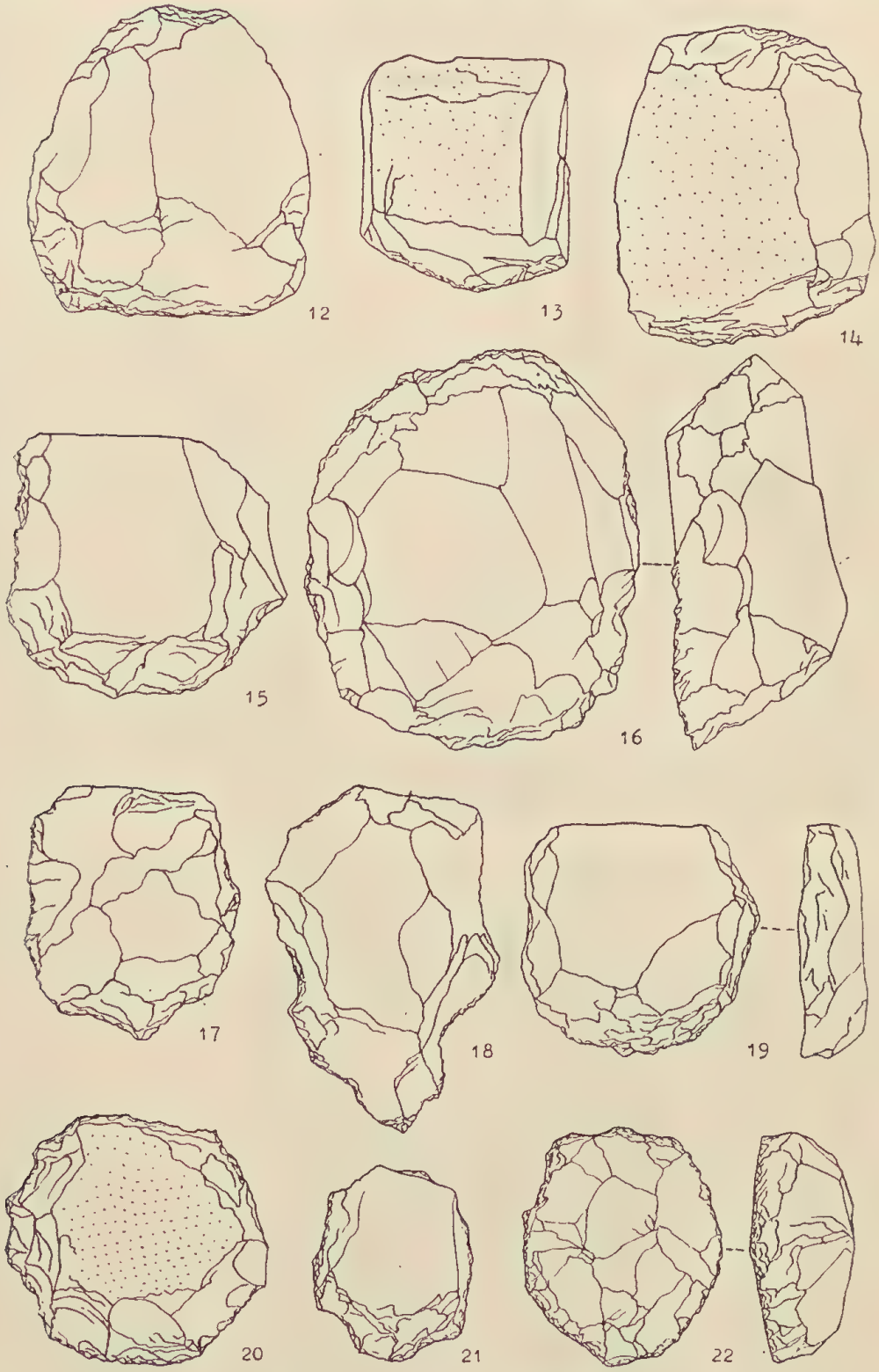
Double side and end.—A series of elongate and broad tongue-shaped blades, trimmed along both lateral margins and the distal end (Fig. 44). The plain butt varies from a rounded cone to a wide flat semi-circular platform, and none are faceted. All but three are *arapia*. Five are almost square flakes. Six are polished from use on the prominent ridges and bulb of percussion on the inner face, extending to most of the surface on two of them; one flat blade bears this polishing on the ridges of its outer face. Three tiny specimens are 2–2·5 cm. long. One (Fig. 47) is a thumbnail scraper, one an abrupt trimmed narrow bladelet, and one is pointed. The balance are 3·5–9·5 cm. long.

Semi-discoidal (Fig. 19).—This group differs from the preceding in one respect only, it is wider than long. The butt is flat, the trimmed edge is semi-discoidal. None have a faceted butt. The trimmed margin on two is in the form of a very broad rounded nose. All but one, which is thin and flat and 3·5 cm. wide, are thick *arapia* 5–7·5 cm. wide. One bears polishing as though from use on the ridges of its inner and outer faces, and one on its inner face.

Discoidal.—The majority are from oval (Fig. 22) to round in shape, but five are rectangular with rounded corners. Most of them are thick flakes, and only two show a prominent bulb of percussion. The ridges on the outer face of three, and the whole of the inner face of one, are polished as though from use. The butt is trimmed away on all examples to form a continuous working edge with the adjoining margins. They are 4·5–8 cm. in diameter.

Distal end.—In the straight-edged series the trimmed margin is transverse on eight, and oblique on five. One (Fig. 28) of the latter is a blade 3·5 cm. long and 2 cm. wide. They are an irregular group. Two are duckbill blades 2·75 and 3·5 cm. long. One is 2·5 cm., the balance up to 7 cm. long.

The convex-edged series also shows wide variation. There are five duckbill blades, one with a faceted butt, 3·5–6·5 cm. long. Two of the longest specimens have a narrow butt and broad trimmed distal edge 5 cm. wide (Figs. 12, 27). One blade has a narrow



Figs. 12-22.—*Arapia.* 12-13, Distal end scrapers. 14, Double end scraper. 15, Side and end scraper. 16-17, Double side and end trimmed blocks. 18, Keeled block with several concaves. 19, Semi-discoidal scraper. 20, Discoidal coroid. 21, Discoidal block. 22, Discoidal scraper. (Two-thirds natural size.)

trimmed end 1 cm. wide. One is trimmed from the outer face, and one has a notched edge. One (Fig. 13) rectangular flake is 5 cm. long and 4 cm. wide; its trimmed end is steep, and its inner face is polished as though from use. One is a carinate scraper 6 cm. long. Two are irregular flakes. There are two thumbnail scrapers; one 2 cm. long is of quartz, and one is thick with an abrupt trimmed end margin. The balance are up to 6·5 cm. long.

Butt-end.—This group includes an exceptionally interesting triangular series (Fig. 25) of fourteen specimens from 2·5 cm. long and wide to 4 cm. long and 5 cm. wide. All have a convex trimmed edge and were evidently gripped in use by the thin distal end, unless they were mounted in gum as adze-flakes, and resemble the *clouera* in having the working edge on the thick margin. All are trimmed on the inner edge of the butt-platform, most of them are steep-faced, and three bear concaves 1 cm. wide. Two similar specimens are trimmed on the outer edge of the butt-platform. Seven are less than 3 cm., the balance up to 5 cm. long.

Double-end.—One specimen (Fig. 14) of *arapia* type, oval in shape, step-chipped across the butt, with a trimmed convex distal end. 6·5 cm. long.

Concaves.

Lateral.—Thirteen have the concave on a thin margin, but it is worked back to form a thick strong edge on the majority of them, and nine have the concave on a thick margin. Three (Figs. 32–33) have a concave on each lateral margin, three two concaves on the one margin, and three (Fig. 34) have one concave adjoining the butt-platform. One of the latter is a thumbnail duckbill scraper 2 cm. long. The concaves are 1–3 cm. wide. Four are blades with faceted butts. Additional trimmed margins form three double-side scrapers, and two have knife edges. Four are less than 3 cm., the balance up to 7 cm. long.

Distal end (Fig. 31).—Five blades have concaves 1–2 cm. wide, and two have double concaves 1 cm. wide. Five are irregular flakes with concaves 1–3 cm. wide. One blade has a faceted butt, and one has a trimmed lateral margin. 4–6 cm. long.

Lateral and end.—Seven have one concave on one lateral margin and on the distal end, four have three or more concaves on various parts of their margins. One has a concave adjoining its faceted butt. One blade 7 cm. long has two concaves on the end and three on a lateral margin, and the other lateral margin is scraper trimmed. Five are blades and two are rectangular flakes. One is less than 3 cm., the balance up to 8·5 cm. long.

Butt-end.—Seven are triangular pieces with a thin distal end and a broad rounded trimmed edge across the butt, with the concave on the inner edge of one and on the outer edge (Fig. 26) of four of them. On the latter four, the faceted edge of the butt-platform has been developed into a concave, and there is a broad thick blade 6 cm. long of a similar type. The concaves are all 1 cm. wide except one, which is 3 cm. wide. Two have trimmed lateral margins, and one a distal end. 5–9 cm. long.

There are two *arapia* in the concave series.

Nosed.—The nose is rounded on twenty-three, and triangular on ten, of which three are narrow and of piercer type. None are straight-ended. Twenty-seven have one nose, and six have two or three noses. It is on a corner (Fig. 35) of the distal end on fifteen. Three are elongate pointed examples of the borer type similar to those from the south coast of New South Wales (McCarthy, 1943, 143, fig. 30) and Singleton (McCarthy and Davidson, 1943, p. 220). The nose is on a lateral margin on thirteen, on the distal end on one (Fig. 40), and on the butt-end on one. Three have noses on the corner and distal end. The majority have a concave on each side of the nose, exceptions being the pointed or corner varieties. Only three are blades, and five have faceted butts. One has a fabricator edge across its butt. Fourteen have additional scraper trimming on lateral and end margins. The nose projects 0·5 cm. from the margin on the majority, but up to 1 cm. on some specimens. One made of quartz is only 2 cm. long. Three are less than 3 cm., the balance up to 8·5 cm. long.

Piercers.—No examples in the collection apart from the three noted in the nosed group.

Burinate.—These are all of the scaled type and are classified according to Noone (1934, 84).

B, I, Bevel-scaled: Oblique line of scales opposed to vertical spall. Two excellent examples, both formed by single spalls. One (Fig. 10) is 3 cm. long, and one (Fig. 9) 2 cm. long is the end broken off a blade. On both specimens the trimmed edge is slightly concave.

One (Fig. 48) has a single spall on the inner face opposed to a skewed line of scales, and is of the "*burin plan*" or flat type. It is 5 cm. long.

B, V, Concave-scaled: concave line of scales opposed to vertical spall. One (Fig. 11) 3·5 cm. long formed by a short spall against a transverse concave edge.

B, VIII, Counter-scaled: scale opposed to scale. The burinate is at the end of a ridged blade. 3 cm. long.

Cutting edge.—Forty-five have one, and fourteen have two, knife edges on lateral margins. Fourteen have a saw-like edge on one margin, and only one has a serrated edge. The cutting edges vary from straight to semi-circular. Fifteen are blades with a faceted butt, and on the balance, half of which are blades, the butt is plain. Six are less than 3 cm., the balance up to 9 cm. long.

Smoothed edges and polishing by use.—A number of scrapers have the ridges on one or both surfaces polished, and in several instances this polishing covers most of the surface of the inner face. The *worimi* has its chord edge polished in a similar manner, and a triangular flake 6 cm. long displays smoothing on its chisel-like distal end. 2 cm. wide, which is trimmed on both facets. This polishing is obviously due to the manner and purpose for which these implements have been employed, and is not grinding such as we see on edge-ground implements. Attention has already been drawn to its occurrence on a limited number of implements from the south coast of New South Wales (McCarthy, 1943, 145). The cause of this polishing is not known. The late Mr. Ivatt suggested that it was due to the implements being used for scraping skins and incising designs on the inside of skin-cloaks.

Flake fabricators.—Sixteen specimens are of the punch type. Six have the fabricator edge at the distal end, and nine at both ends. Three are slender blades 5·5–6 cm. long. One is of quartz (Fig. 29). They range from six less than 3 cm. to a blade 6·5 cm. long and 4·5 cm. wide (Fig. 30), the latter being the longest punch type yet recorded.

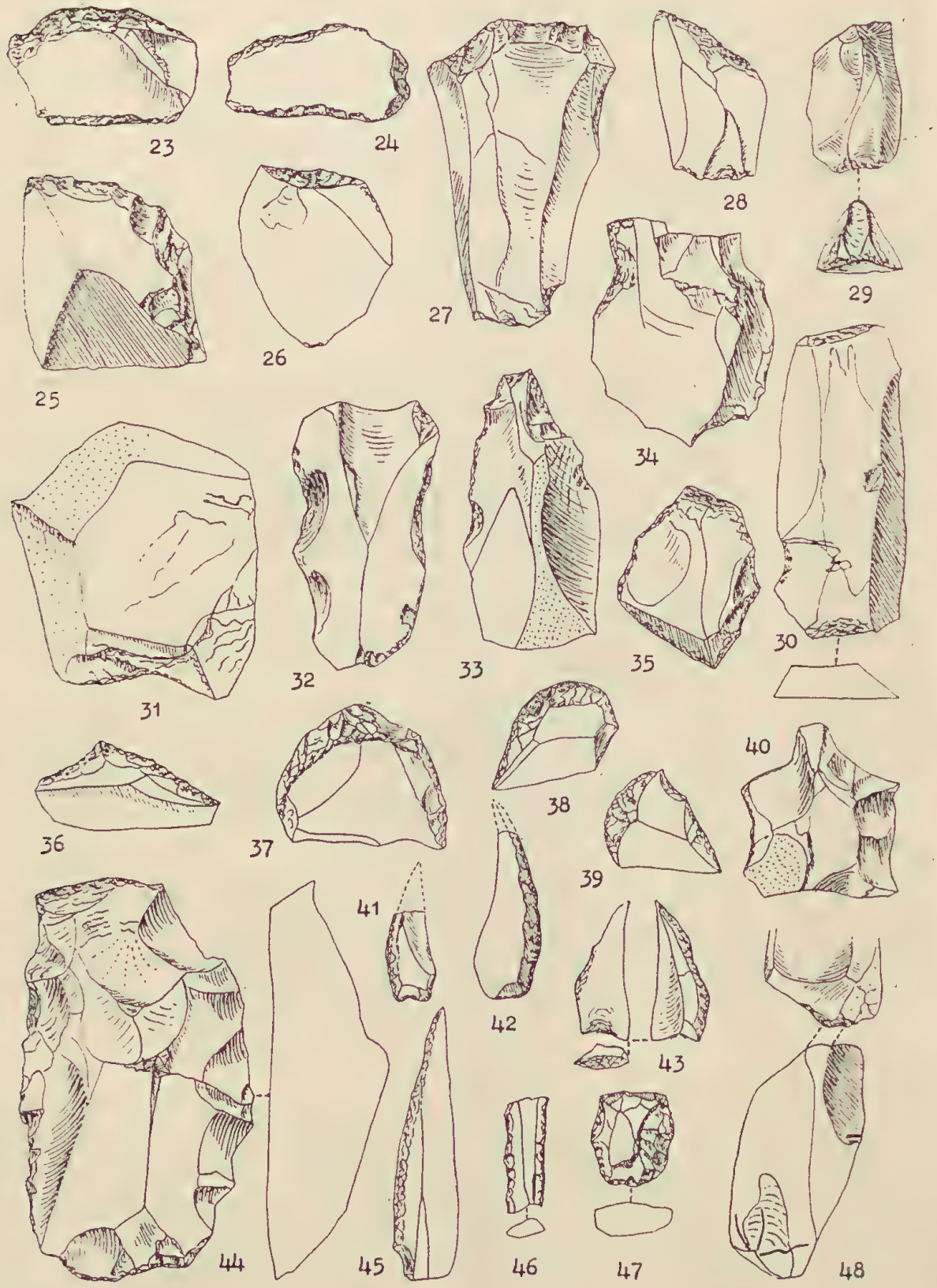
One has a lateral fabricator edge. One is irregular in shape, and battered on a number of its edges. One has a very thick battered butt end 5 cm. wide. One has several patches of battering on its oval margin. 4–6 cm. long.

Flake fabricators are thus more commonly represented in this area than at Singleton, but not as plentifully as on the south coast of New South Wales. In this respect attention might be drawn to the scarcity of geometrical microliths, *bondi* points, and *elouera* at Bathurst. The late Mr. Ivatt did not find any bone fabricators. Both at Bathurst and on south coast stations pebble and trimmed coroid hammerstones are abundant.

V. Bondi Points.

Although the series is a small one, it conforms in all respects to the *bondi* points of the south coast of New South Wales (McCarthy, 1943, 145–149, figs. 37–69), and Singleton (McCarthy and Davidson, 1943, p. 221, figs. 41–43, 45). Blades of triangular transverse section are more numerous than those of trapezoidal section. In width the majority are less than 1·5 cm., but two of 2 cm. are short and squat, and one of them is oblique trimmed. The majority are straight-edged on the thin margin, but five are in-curved or hook-like. Only two are rudder-shaped. The trimmed convex margin is convex on the great majority, and is straight on a few specimens only. The trimming is even and neat (Fig. 45). The butt where trimmed is rounded on the majority, but is straight on two (Fig. 42). The faceted butt is represented.

In the single-edged series two have a concave butt 0·75 cm. wide (Fig. 43), in each case worked by use into the inner edge of the butt-platform. One (Fig. 41) has a small rounded nose between two concaves on the inner edge of the butt-platform and toward the thin margin. One has a trimmed oblique distal end and lateral margin, both edges being slightly concave.



Figs. 23-48.—23, *Elouera*. 24, Double side scraper. 25-26, Butt end scrapers. 27-28, Distal end scrapers. 29-30, Punch-type flake fabricators. 31-34, Concave scrapers. 35, 40, Nosed flakes. 36, Nosed blade. 37-39, Geometrical microliths. 41-43, 45, *Bondi* points. 44, Double side and end trimmed blade. 46, Double side trimmed microlithic blade. 48, Bevel scaled and skewed burinate. (Two-thirds natural size.)

The majority have lost their tips, but none of the complete specimens is trimmed on the thin margin at the distal end. Scraper and knife edges on this margin are both present in the series.

Sizes: The following is an analysis of the lengths of the points: 0–2 cm., 2; 2–3 cm., 5; 3–4 cm., 11; 4–5 cm., 5; 5–6 cm., 4.

VI. Geometrical Microliths.

This is an unimportant group in the collection, being represented by three crescents and two scalenes. There are sixty-five specimens less than 3 cm. long among the normal flake and blade implements.

Segment.—One (Fig. 37), 3·5 cm. long, 2·5 cm. wide, is a large semi-circular example made from a faceted butt blade. One, 3 cm. long, is narrow and very thin. One (Fig. 38), 2 cm. long, is of the squat type.

Scalene (Fig. 39).—Two, 2·25 cm. long, have trimmed rounded margins.

Discussion.

N. B. Tindale and B. G. Maegraith proposed the name *arapia* for large flakes, roughly fashioned to a discoidal shape, with secondary trimming on portions of their periphery (1931, 281 and 286, figs. 6–7, 10–11). Their distribution embraced examples collected on Kangaroo Island, at Hawk's Nest, to as far north in Australia as Durham Downs in south-western Queensland. The specimens from the Bathurst district noted as *arapia* in this study agree so closely with those figured by the above authors that it has been considered advisable to retain the name for them in the block and the normal flake and blade groups, thus extending their distribution considerably eastward. They comprise end, side, side and end, double side, double side and end (or tongue-shaped), semi-discoidal, and discoidal varieties. The discoidal variety has had its butt-platform removed by trimming, which extends right round the margin; it is considered to be the ideal or standard form of *arapia*, just as variety iii of the *elouera*, which also has its butt trimmed to a rounded end, occupies a similar position at the head of the *elouera* series.

C. C. Towle described and figured (1935, 132, pl. vi, fig. E) the discoidal variety from far western New South Wales, and stated that "the presence of circular scrapers indicates the use of a superior material which could readily be retouched in that manner"; as I see it, the presence of discoidal scrapers is due to function and to the requirements of the workman rather than to the material used because the latter is of poor quality in many Bathurst specimens.

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THE *ELOUERA* INDUSTRY OF SINGLETON, HUNTER RIVER, NEW SOUTH WALES.

By Frederick D. McCarthy,
The Australian Museum,
and
F. A. Davidson.

(Figures 1–135.)

In 1941, one of us (F.A.D.) discovered a workshop and camp-site at Gowrie, three miles west of Singleton, on the northern bank of the Hunter River, and in the territory of the Wonarua horde of the Kamilaroi tribe. Since that date he has visited the site regularly, and this paper is an analysis of the specimens that he has collected, and of those gathered by both of us during a week spent in the area in June, 1943. The collection, totalling 2,451 specimens, has been presented to the Australian Museum. This study is the third of a series analysing New South Wales industries.

The implements occur on a terrace about two hundred feet above the river and adjacent alluvial flats. They are embedded in the top six-inch layer, which consists of a fine silt and is lying upon a coarse gritty clay of great depth; at the base of the terrace is a thick layer of water-worn pebbles. On the northern side of the valley the implements are particularly abundant on a tongue of land enclosed by a bend of the river at Gowrie, and their occurrence was traced for about ten miles along the terrace and is probably more extensive. Visits have been made to two parts of the terrace on the southern side of the valley, one six and the other six and a half miles east of Singleton, and to another section opposite Gowrie, about four miles across the valley, and in each locality the implements were found.

Mitchell (1838, II, 14) described the Hunter valley as being thinly wooded and bearing in most parts a good crop of grass. This description still applies to the terrace, but it has been cleared of trees where necessary for the grazing of cattle. It is eroded by numerous natural drainage gullies running from its highest points to the flats and river, and its margin consists of rounded hills and creek beds, plateaus round which the river flows, and high alluvial cliffs into which the river is cutting in the great bends, as at Gowrie.

Materials.

The predominant material is chert of all shades of colour from cream to red, grey being scarce. Other materials commonly used are jasper, quartzite, porphyry, and conglomerate. Igneous rocks occur among the river gravels at the base of the terrace, and this deposit formed the source of the materials.

Technique.

The use of fine-grained stones such as those mentioned above did not cause the makers of these implements to diverge from their traditional types, as might be expected from a comparison of their excellent materials with the poor quality, refractory rocks used on the south coast of New South Wales (McCarthy, 1943, 129–30). Although the techniques appear to have been the same in both areas, they are more specialized and are more clearly demonstrated by the artefacts at Singleton, where prismatic cores bearing convergent flaking predominate and flakes and blades with faceted butts are commonly found. It might be mentioned that the faceted butt technique was employed mainly for the production of blades, and it appears frequently among the *bondi* points

and blades used as scrapers and knives; it is rarely seen on blocks. Squat and stout flakes with plain butts are well represented at Singleton.

On the cores the striking-platforms are formed by the usual methods, embracing the removal of one or more flakes, the use of the cleavage face on block cores, and the use of the flat crust on some of the pebbles. Multi-platform cores are also formed by the use of one or more knapping faces as striking-platforms, and several cores of this type have been worked progressively, that is to say, the end of the knapping face has served as a second striking-platform when it was found by the knapper that it was not possible to strike a narrow blade the full length of the original face owing to a fault in the stone (Fig. 74). The napping face is at an angle varying from 70° to 85° to the striking-platform.

The industry is a mixture of symmetrical flakes and blades, and of squat and stout flakes. Slender symmetrical blades trimmed back to the central ridge or to the first ridge from the margin, and asymmetrical blades, were struck off for the making of *bondi* points. Blades of both types were utilized for *elouera*. The inner platform angle on the normal flake and blade implements varies from 95° to 135°, and mostly between 110° and 120°. Trimming and retouch on the various implements are the same as on South Coast stations.

Although suitable pebbles are abundant in the river pebble layer at the base of the terrace, they were not used as hammerstones as commonly as one would expect, and only one broken pebble hammerstone was found. Signs of percussive use are common on trimmed coroids, blocks and uniface pebble implements. Flake fabricators are poorly represented, only eleven specimens being collected, and no bone or shell implements occurred.

When collecting we sometimes came across a core and set of flakes left by a knapper, among which were trimmed flakes and up to as many as fifteen geometrical microliths. Similarly, up to six *bondi* points were found in a group. Both the microliths and points appear to be unused. At one station, one of us (F.A.D.) recorded finding forty-three geometrical microliths and eighteen *bondi* points, but as a general rule the latter are more abundant than the former, and both types are scarce in some sections where cores and flakes are abundant.

Artefacts.

The 2,451 implements comprise 257 cores, 58 cores used as implements, 89 uniface pebble implements, 112 blocks, 15 *worimi*, 8 cleavers, 788 normal flake and blade implements (including 89 *elouera*), 524 *bondi* points, 245 geometrical microliths, and one edge-ground axe blade. Attention should be drawn to the abundance of *bondi* points and geometrical microliths, and to the scarcity of *elouera*, *worimi*, and cleavers, and in these respects the analysis supports impressions gained on the stations when collecting. The composition of the industry at Singleton, in regard to the trimmed coroid and knapped implements, agrees closely with that at north Cronulla (Boat Harbour and Quibray Bay) on the south coast of New South Wales (McCarthy, 1943, 131–33).

I. Coroids
- *Cores* (257)
  - one striking-platform 99
  - two striking-platforms at opposite ends 50
  - two or more striking-platforms at angles to one another 95
  - conical 8
  - discoid 5
- *Core implements* (58)
  - straight to convex edges 28
  - concave 17
  - nosed 5
  - burinate 3
  - biface discoids 5
- *Uniface pebble implements* (89)
  - end 36
  - lateral 32
  - end and lateral 7
  - bilateral 2
  - uniface 4
  - split-pebble 8

II. Blocks (127)
- Crown
  - straight to convex edges 23
  - concave 21
  - nosed 12
- Keeled
  - straight to convex edges 18
  - concave 23
  - nosed 15
- *worimi* 15

III. Cleavers (8)

IV. Normal Flake and Blade implements (788)

Elouera
- type 1 28
- type 2 33
- type 3 28

Scrapers
- side 120
- side and end 12
- double side 35
- double side and end 20
- distal-end 67
- butt-end 19
- double-end 6
- concave
  - lateral, lateral and end 115
  - distal-end 37
  - butt-end 7
- nosed 126

Utilized 10
Piercers 17
Burinate
- spalled 10
- scaled 2
- utilized 6

Knives 52
Serrated 27
Fabricators 11

V. *Bondi* points (524)

Conformation
- left 324
- right 200

Trimmed on single edge
- (*a*) distal end and plain butt 105
- (*b*) distal end and butt 6
- (*c*) distal end and faceted butt 55
- (*d*) completely 159

Trimmed on two edges
- (*e*) distal end and plain butt 24
- (*f*) distal end and butt 3
- (*g*) distal end and faceted butt 3
- (*h*) completely 169

Butt
- plain 139
- faceted 58
- trimmed 327

Thin margin trimming
- knife 33
- scraper 29
- point only 12

VI. Microlithic (245)

Geometrical
- trapezoid 118
- segment 39
- equilateral 11
- isosceles 14
- scalene 56
- right-angled 4
- special pieces 3
- oblique trimmed blades .....(33)

Normal flake and blade (173)
- abrupt trimmed blades and side ... 40
- side and end 3
- double side 6
- double side and end 3
- distal end 22
- butt end 5
- double end 5
- concave 25
- nosed 25
- piercers 2
- knives and serrated 7
- utilized ..... —
- burinate 1
- fabricators 2
- *elouera* 27

VII. Glass and crockery (232)

Scrapers and knives 100

Scrapers
- end 20
- concave 84
- nosed 17
- piercers 11

I. Coroids.

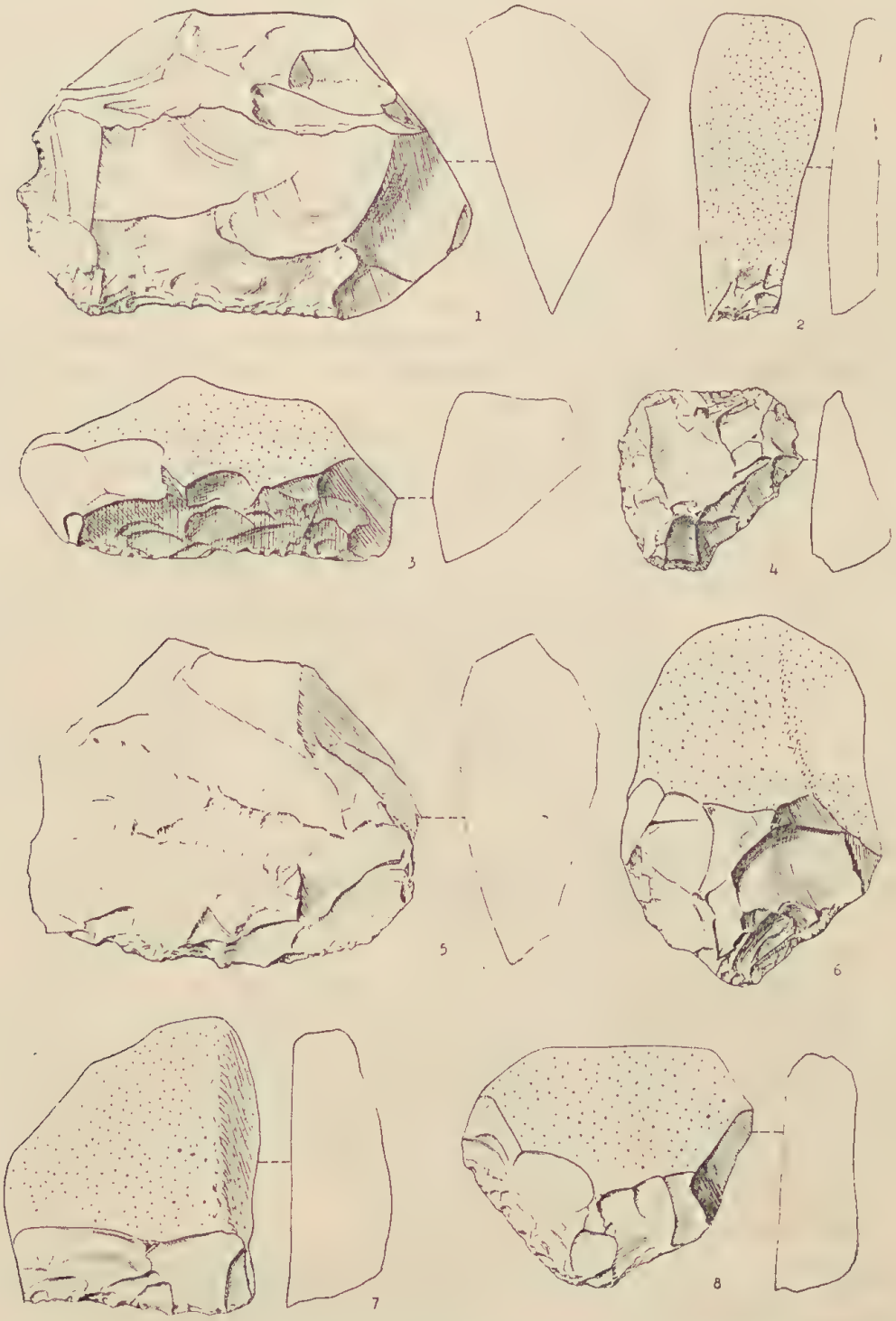
Cores.

A splendid series of cores ranging from small nuclei 2 cm. long to large lumps 11 cm. long from which a few flakes only have been knapped. Those with one striking-platform are in the majority, followed by the multi-platform group, while those with two opposed platforms (Fig. 73) are in the minority. There are numerous nuclei in the multi-platform group. The 81 prismatic cores (Figs. 71–72) are from 2·5 to 6 cm. long; many are pyramidal in shape, tapering from the striking-platform to a sharp edged or pointed distal end, or to another platform, and some have a crust surface opposite the knapping face. It might be noted that most of the prismatic cores fall within the range of sizes of the *bondi* points and, as they bear long narrow flake scars, are probably point cores. There are two cores with semi-discoidal and two with discoidal margins knapped from upper and lower surfaces, and they are from 3 to 5 cm. in greatest diameter. The eight conical cores (Fig. 12) have a cleavage face as their striking-platform, and they are from 6–9 cm. in greatest diameter; several of them are similar in many respects to the *horse-hoof* type (Tindale, 1937, 52, fig. 15) of the interior of Australia. Globular cores are not represented, apparently because the homogeneous materials permitted the knappers to prepare with ease a prismatic or other variety of core with the knapping face at a suitable angle to the striking-platform. Tortoise cores are also absent. There are two pebble cores knapped at one end, each with one striking-platform (McCarthy, 1943, 135).

Cores used as implements.—The majority are small nuclei from 2·5–7 cm. long, which have been utilized on various parts of their margins. One is shoe-shaped, 12 cm.

long, and bears step-chipping in a shallow notched style on both lateral margins and one end. Three have straight trimmed margins at one end. The concaves are 1–4 cm. wide and several are worked back under the edge; one has a concave on each lateral margin. There are five rounded noses and one triangular nose. One keeled specimen is a rolled and heavily patinated elongate piece of chert 8 cm. long, bearing a sharply trimmed nose between two concaves at one end, but the chipped area is not patinated.

A series of what appear to be thin discoid biface implements (Fig. 77) are in reality core nuclei which have been skilfully knapped on both sides. They are from 3–4 cm. long, and have from two to four striking-platforms, those on one surface being at a different angle from those on the other; alternate flaking is shown by the flake scars where there is a platform at each end of one surface. Most of them bear secondary trimming on various parts of their margins.



Figs. 1-8.—1, *Worimi*. 2-4, 6-8, Uniface pebble implements. 5, Split pebble implement. (One-third natural size.)

Nucleiform burinates.—Two specimens, of which one is narrow and one is broad, are 3 cm. long, and a third one (Fig. 70) is 8 cm. long. The burinate edge is formed by one spall on two, and two spalls on the other one. The two short specimens bear trimmed scraper edges on their margins. They conform to the group classified by Noone (1934, 84, fig. 2, f) as A—spalled, VI—vertical spalls from margin and face, with horizontal platform.

Uniface pebble implements.

This forms an important group in the industry, and the series includes all varieties hitherto described in New South Wales. They are made of chert or quartzite, and show finer flaking and trimming than those from coastal sites where coarse materials were used in their manufacture; the steeply sloped working face is often heavily worked with long spall-scars and fine retouch, and the edge may be serrated or notched in outline when viewed from the lower surface. In shape they are round, oval, rectangular, and triangular, often flat on the lower surface and convex on the upper surface. Some are broad and long but comparatively thin, others are short, thick and squat, and some are as small as 4 × 4 × 1 cm. In thickness they range from 1 to 6 cm. Most of them are flat on both surfaces, and a few are keeled, thus retaining the original form of the chert pebbles. It is not possible to distinguish a crudely flaked from a carefully trimmed series because they all belong to the latter category. The end and lateral varieties predominate, and the other varieties are scarce. Remarks on the specimens, classified according to the working edges, are as follow:

One lateral margin.—The working edge is from straight to convex on twenty-three, and concave (Fig. 3) on six. One (Fig. 8) bears a broad nose, 3·5 cm. wide, with wide concaves on each side, in the middle of its trimmed margin, and one, triangular in shape, has a small rounded nose. 6–12 cm. long.

End (Figs. 2, 7).—The working edge, 2–10 cm. wide is from straight to convex on eight, concave or notched on six. Three have a well trimmed nose and a piercer-like projection. Six are triangular in shape. One (Fig. 6) has a keeled lower surface, and both margins of the V-shaped end are trimmed. 5–12 cm. long.

One end and one or both lateral margins.—Four are unilateral and end, one of which is a thick high-crowned lump with its trimmed margins at right angles to one another and is similar to a specimen from Port Kembla figured by McCarthy (1943, 136, Fig. 8*a*). Three are bilateral and end, and two are bilateral. Two bear concaves and a nose on the same margin. One is triangular in shape. 6–11 cm. long.

Uniface.—Two discoids (Fig. 4) trimmed all over one surface, 6 cm. in diameter, and made of chert. There is one *hache-courte*, or one end of a larger implement, which shows the characteristic technique of the *sumatra*-type; it is made of a grey igneous rock and is 7 cm. wide.

Split-pebbles trimmed on edge of cleavage face (Fig. 5).—Four are unilateral, three bilateral, and one lateral and end trimmed, and all have convex working edges. 10–14 cm. long.

II. Blocks.

Crown.—Among those with from straight to convex (Fig. 76) working edges, eight are 3–6 cm., ten are 7–11 cm., and four, which have well trimmed semi-discoidal (Fig. 11) and discoidal edges, are 8–10 cm. long. One of the latter is rectangular, and is trimmed on adjoining margins. One (Fig. 22) is tongue-shaped, high-crowned, and trimmed along both lateral margins and distal end, with a plain butt-platform. Two are pieces struck from prismatic cores, one of which has a steep-faced working edge at one end, and the other has a trimmed oblique edge.

Those with concaves, which are 1–3 cm. wide, range from 4 to 15 cm. long, and form an irregular series. The concaves occur on semi-discoidal edges on several specimens. One tongue-shaped example has a long sloping face, and is trimmed all round its margins excepting the butt, and at the distal end there is additional trimming on the edge of the cleavage surface, thus forming a biface margin. The largest specimen,

15 cm. long, is oval and domed in shape, and has two step-chipped concaves, one 6·5 cm. wide and 3·5 cm. deep, the other 3 cm. wide and 1 cm. deep. Another domed specimen 7 cm. long has a shallow concave 3·5 cm. long.

The nosed series bear from one to three noses 0·5–3 cm. wide. One is of particular interest; it is a bean-shaped block, bearing at one end a sharp peaked nose, 0·5 cm. long, between two concaves each 1 cm. wide, and an additional nose forms the corner round which the trimming leads to the lateral margin. One (Fig. 75) is 5 cm. long, and has a narrow prominent nose 1·25 cm. long set between two deep concaves on its lateral margin. 5–10 cm. long.

Keeled.—The majority are longer than wide, but they do not conform to any particular or uniform shape.

Among those with straight to convex working edges seven are 3–7 cm., and seven 8–13 cm. long. Eight have semi-discoidal trimmed margins, two of which are oval and domed with two trimmed lateral margins, and are 7·5 and 12 cm. long. One (Fig. 10) is tongue-shaped, has a median keel and a plain butt, and is trimmed along both lateral margins and the distal end.

The concave series comprises eleven small blocks 4–7 cm., and eleven heavier lumps 7–15 cm. long. The concaves are 1–5 cm. wide, and extend the full length of the margin on some specimens; they occur mostly on lateral margins, but five are on end margins, while straight to convex trimmed edges occur on other parts of the margins. One narrow piece, 10 cm. long, has a concave 3 cm. wide worked into the distal end of its outer crust surface.

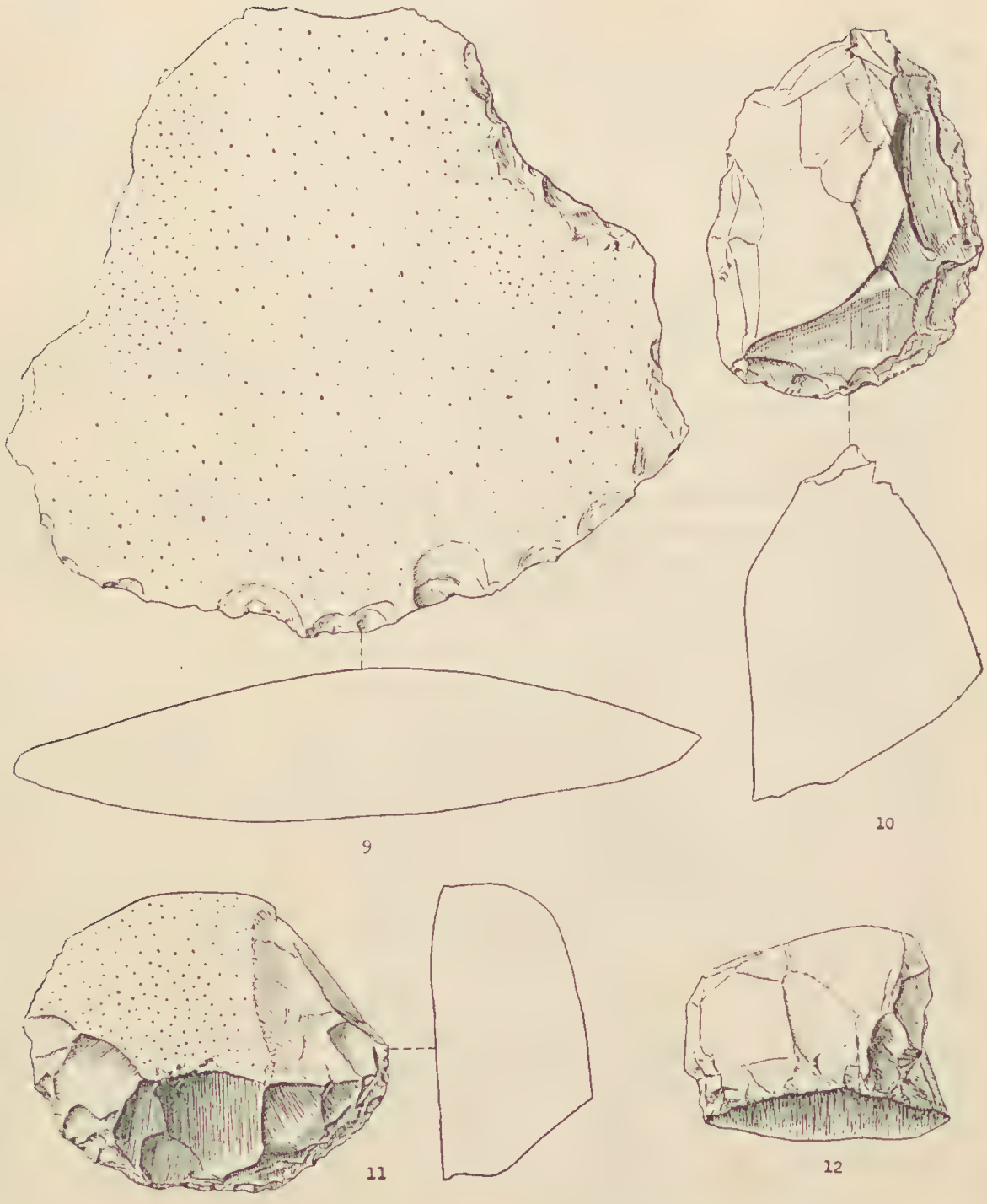
In the nosed series, from one to three noses are present, and they are either flattened, ridged or steeply convex on the trimmed surface. One, 7 cm. long, has a broad rounded nose on one end of its butt-platform. One is triangular, with two long trimmed margins leading to the nose and is of the borer type. The largest specimen is rectangular, has a median keel, its trimmed end and lateral margins form a right angle, and it bears two ridged noses on two corners. One has the trimming extended across the edge of the butt-platform to form a broad concave edge leading to a rounded nose 2 cm. wide. 4–8 cm. long.

Worimi.—Eight are normal blocks 7–11 cm. long, with the chord or thin margin trimmed from the cleavage surface along one lateral margin and end on six specimens, and on two lateral margins and end on the other two. One has ridged peaks on three corners which appear to have been used for graving, and several concaves. On three (Fig. 1), 8–13 cm. long, which have been quartered off large pebbles, there is an outer crust and an inner cleavage surface, and they are trimmed from the former; they are similar to the example from Crescent Head figured by McCarthy (1941, 24, pl. vi, fig. 11). Two have long slightly concave edges, and one has a broad concave beside an equally wide nose, each 3 cm. wide. One, which is 10 cm. square, has a deep concave 4 cm. wide, a trimmed nose 1·5 cm. wide, and another concave 2 cm. wide in that order on the same margin. One, which is 7·5 cm. long, has a notched edge of three noses and four concaves on its lateral margin and a trimmed convex edge on the adjoining end.

It might be mentioned that the *worimi* is a chopper of triangular section, usually made from a block. Its relationship to the lateral-edged uniface pebble implement has been discussed by McCarthy (1943, 138–9). Some specimens bear a superficial resemblance to the *elouera*, and it is not possible to distinguish the two groups by minimum and maximum dimensions; the essential difference is that the *worimi* is a chopper and its principal working edge is the chord or thin margin, whereas the *elouera* is a scraper-knife tool with the most pronounced trimming on one or both edges of its thick margin.

III. Cleavers.

There are several interesting pieces in this series of large slices knapped from pebbles. Two have evenly trimmed convex edges, one is serrated and concave, and one is notched, in a group 8–10 cm. long. A large oval specimen 14 cm. long has a flaked and trimmed convex distal end, one of the same size has two concaves on its lateral margin,



Figs. 9-12.—9, Tanged cleaver. 10, Keeled block, double side and end trimmed. 11, Crown block, semi-discoidal edge. 12, Conical core. (One-half natural size.)

and one 11 cm. long is a discoid cleaver. One has the outer edge of its butt-platform trimmed, and a concave on the adjoining margin.

The most interesting specimen (Fig. 9) is tanged in shape, 15 cm. long and 3 cm. thick; the trimming extends round the broad concaves on each side of the tang, which is 8 cm. wide, and across the convex blade end, which is 17 cm. wide. The trimming is done from the inner or cleavage surface on one margin of the tang, and from the outer or crust surface on the other margin; the same reversal of trimming occurs on the blade end. It weighs 1 lb. 6 oz. Although in outline this specimen resembles the tanged implements described by Casey (1934), it does not belong to this group, which are all coroids and much heavier. They are, in addition, finished off by hammer-dressing and polishing, and it is obvious that this specimen was not intended to be treated so carefully.

IV. Normal Flake and Blade Implements.

The chert and jasperoid rocks predominate among the materials used in this group.

Scraping and Cutting edges.

Elouera.—The three varieties defined by McCarthy (1943, 139–40, figs. 17–19) are evenly represented in the series. Scraper trimming is present on the chord (Fig. 19), which is often slightly concave, on forty-five specimens, a relatively high proportion, of which there are fifteen in each variety. Knife and saw edges are present on this margin on the majority of the remainder. Secondary uses are limited to concave and nosed edges. Remarks on the varieties are as follow:

(1) One of chert, 7 cm. long, is heavily retouched along both edges of the thick margin. Three have concaves on the edge of the thick margin. Ten are less than 3 cm., the balance up to 7 cm. long.

(2) Five have concaves on the thick margin and one on its distal end. Several (Fig. 16) have scraper trimming limited to the distal end, but show knife use on the chord. The largest *elouera* (Fig. 13) of the collection is in this group; it is 8·5 cm. long, of equilateral triangular section 3 cm. wide, notched and scraper trimmed on the chord with a concave in the middle, and the butt is rounded but not trimmed. Another specimen has three notches on the chord. Seven are less than 3 cm., the balance up to 8·5 cm. long.

(3) On six specimens is a narrow, rounded edge formed by long narrow spall-scars at the distal end, which could have served as a nosed graver. One has a concave on the outer edge, and one on the inner edge, of the butt-platform. One (Fig. 15) has a trimmed nose and concave at the distal end. One has a concave on the distal end. One is hat-shaped in outline. One (Fig. 14) has concaves on both margins. Ten are less than 3 cm., the balance up to 7 cm. long.

Utilized.—The flakes and blades in this group exhibit scraper and knife use on various parts of their margins. Six are blades. The largest example is oval and has an outer crust surface. One is like a broad, flat *elouera* and has a long knife margin, with serrated trimming on the opposite and thicker margin. One is a blade 4 cm. long with one knife and one scraper margin. None has a faceted butt. There is a concave on one thin blade. 4–9·5 cm. long.

Scraping edge.

Side.—A mixed series of blades and scrappy flakes, some of which are thick, and many are well used and carefully retouched. Seven (Fig. 83) are abrupt trimmed blades 3–5 cm. long. One (Fig. 17) is a segment with a crust back. Only four have faceted butts. Forty are less than 3 cm., the balance up to 7 cm. long.

Side and end.—Nondescript flakes have been utilized in this group. One keeled specimen (Fig. 18) has a nose-like corner. One has a faceted butt. This group is well represented among the concave and nosed scrapers. Three are less than 3 cm., the balance up to 7 cm. long.

Double side.—Nineteen have both lateral margins trimmed from the inner face, and four of these are pointed flakes. Six (Fig. 20) are trimmed on one margin from the inner face and on the other margin from the outer face. One is a plunged flake trimmed from the outer face. None has a faceted butt. Six are less than 3 cm., the balance up to 5·5 cm. long.

Double side and end.—Eleven are tongue-shaped, three semi-discoid, two trapezoid, and four irregular flakes. The majority are thus carinate scrapers. One has one concave lateral margin and end worked from the inner face, and the other lateral margin is worked from the outer face. Several bear tiny noses. Two have faceted butts. Three are less than 3 cm., the balance up to 8 cm. long.

Distal end.—In the straight-edged series the trimmed margin is transverse (Fig. 23) on the majority, and oblique (Figs. 24, 78–81) on twenty-six specimens, the latter forming a well marked variety. Five are less than 3 cm., the balance up to 6 cm. long.

In the convex-edged series (Fig. 28) three are duckbills 2–5·5 cm. long, and seven (Figs. 25–26) are microlithic thumbnail scrapers. One (Fig. 21) is a semi-discoidal *tula* type, 3 cm. wide, and it has a steep-faced, step-chipped working edge wider than the

Figs. 13-39.—13-16, 19, *Elouera*. 17, Side scraper. 18, Side and end scraper. 20, Double side scraper. 21, *Tula*. 22, Side and end trimmed block. 23-28, Distal end scrapers. 29-32, Butt end scrapers. 33, 35, Double end scrapers. 34, 36, 39, Serrated blades. (Two-thirds natural size.)

butt-platform. One ogival-shaped example (Fig. 27) is worked from the inner face half-way to the middle of the end, and from the outer face along the other half of the margin. A series of specimens with faceted butts includes five elongate narrow blades; the trimmed distal end is straight on two, oblique on two, convex on two, and concave on two. Eighteen are less than 3 cm., the balance up to 7 cm. long.

Butt end.—Eight are trimmed, two obliquely (Fig. 32) on the inner edge of the butt-platform. Thirteen are trimmed on the outer edge (Fig. 30), and although some of them have faceted butts, they appear to bear additional retouch and signs of use. One has the trimming at the upper edge of the scar-face adjoining the butt-platform, and the edge is concave. One (Fig. 29) is beautifully trimmed along both lateral margins, which are straight, and on the inner, slightly concave edge of the butt-platform; it is 5 cm. long. Five are less than 3 cm., the balance up to 8 cm. long.

Concave.—Only four have faceted butts. Some are segments with a crust back. The variation in the widths and depths of the concaves indicates a wide range of uses, and the various kinds are shown in Figures 40–48. Remarks on the varieties are as follow:

(*a*) *Lateral margin.*—Thirteen have the concave on a thin margin, but on the majority of these it is worked back to form a thick, strong edge. Several concaves are on delicate flakes. Seven have the concave adjoining the butt-platform (Fig. 41). The concaves range from 0·5 to 3 cm. wide, and up to 0·75 cm. deep. Some are on blades, but the majority are on nondescript flakes. Many bear additional trimmed convex and straight working edges. Ten have two concaves on the same or on opposite margins (Figs. 40, 46–47). One has a long trimmed convex edge between two concaves. Ten are side and end scrapers in addition to their concaves. Eleven (Fig. 45) are less than 3 cm., the balance up to 7 cm. long.

(*b*) *Distal end.*—Twelve blades (Figs. 42, 44) have narrow concaves from 0·5 to 1 cm. wide, with peaks on both sides, occupying the whole of the end margin, and on one of these the concave is 2 cm. wide. Fifteen have concaves up to 2 cm. wide on a longer end margin, five of which are broad blades; one of the latter is a rhomboid, with a narrow concave in the middle of the distal end. Four are side and end scrapers in addition to their concaves. One large flake, with crust outer surface, 9 cm. long, has a concave 2 cm. wide. Several are blades with a faceted butt and distal end concave. Nine are less than 3 cm., the balance up to 4 cm. long.

(*c*) *Lateral margin and distal end.*—Most of the concaves are about 1 cm. wide, but two are 2·75 cm. One (Fig. 43) is a narrow blade, with a concave 2 cm. wide across the distal end, and it has another one of the same width on its lateral margin. One has three concaves on one lateral margin, and one on the distal end. One has a concave on each of three of its four margins. The twelve examples are mostly irregular flakes. Five bear three or more concaves scattered round their margins. Six are less than 3 cm., the balance up to 5 cm. long.

(*d*) *Butt end.*—Six (Fig. 30) have the concave on the inner edge, and one on the outer edge, of the butt-platform. The concaves range from 1 to 1·5 cm. wide. Three have trimmed straight or convex edges at the distal end. Three are less than 3 cm., the balance up to 4·5 cm. long.

(*e*) *Double end.*—Five specimens of small size, 2–3·5 cm. long. One (Fig. 33) has a concave on the distal end and an oblique straight edge on the outer edge of the butt-platform. Two have a concave on the inner edge of the butt-platform, one of which has a trimmed straight edge, and the other a concave with two small noses, at the distal end. One has a concave on the outer edge of the butt-platform and a trimmed straight edge at the distal end, and it is wider than long. One has a concave at each end, but it is a poorly shaped rounded flake.

An exceptionally interesting specimen (Fig. 35) is almost square in shape, and 3 cm. long. The butt is 1 cm. thick, and is formed by two converging and faceted edges of scar-faces, one of which is heavily trimmed from the outer face, and the impact spot is opposite their junction. One lateral margin is a knife edge, and the other lateral margin and distal end are scraper-edges trimmed from the inner face.

Nosed.—The nose is triangular on thirty-four specimens and is rounded on the balance. The types of noses are shown in Figures 38, 49–56. Sixty-two have one nose, and the remainder two or more. Only twelve are blades, the others being irregular flakes. On two the trimmed margin is almost completely discoidal, and on ten it is semi-discoidal (Fig. 38). Three are thick flakes with a rounded nose forming their distal ends (Figs. 49–50). One (Fig. 52) is a carinate scraper with two noses. Two (Fig. 51) have long narrow noses projecting from the lateral margin and are of the borer type. One has noses, bounded by pairs of concaves, at each end of a trimmed straight margin, and two more noses separated by a concave at the opposite end. One resembles a specimen from Lake Illawarra (McCarthy, 1943, 143, Fig. 30); it is an elongate tapering blade, with a nose at the apex, and two small flakes have been removed at the base of the nose, the latter being 0·75 cm. wide and long and suitable for boring use. The nose projects up to 0·75 cm. from the margin, but on the majority up to 0·5 cm. only. Some bear untrimmed sharply-pointed projections in addition to the nose. Twenty-five are less than 3 cm., the balance up to 10 cm. long.

A distinctive variety has a straight-edged rectangular nose (Figs. 55–56) projecting sharply from the margin, with the usual concaves on each side; the working edge is straight, 0·25–1 cm. wide. There are nine examples of this variety, and five are on blades. The type also occurs on the south coast of New South Wales (McCarthy, 1943, 143, fig. 35).

It might be mentioned that projections from the margins of implements are utilized for noses by simple trimming, but where they are not available it is necessary for the workman to form a nose by making two concaves and trimming the projection between them. If the nose was used for engraving, the concaves would enable it to penetrate more deeply into the wood. The large numbers of concave and nosed tools suggest that the industry was the product of a people who used wooden weapons, utensils, and other articles.

Piercers.

One is a ridged thumbnail scraper with a tiny point on a semi-discoid edge. One (Fig. 60) has a point at one end between two oblique concaves, and an oblique concave at the other end with a piercer point on the corner. One is of *elouera* shape, has a piercer point on one corner, two concaves with a sharp nose between them, and a rounded nose on the other corner; its lateral margin is trimmed. The finest example has a long narrow piercer in the middle of its convex lateral margin (Fig. 59). Ten are short, triangular points similar to the nose but definitely of the piercer type, and apart from one blade are irregular flakes. Two (Figs. 57–58) are elongate pointed blades trimmed on both oblique margins leading to the distal end; one of these is roughly serrated, and has a concave on one margin. One is an oblique trimmed blade, 3·5 cm. long, with a concave serrated thin margin, and the trimming on both lateral margins meets at the distal end to form the piercer point. Six are less than 3 cm., the balance up to 5·5 cm. long.

Burinates.

The range of types is similar to that from the south coast of New South Wales (McCarthy, 1943, 143–4, figs. 96–103), but there are none among the *bondi* points. The classification followed is that of Noone (1934).

A. *Spalled.*

(1) *Central (bec-de-flute)* (Fig. 61):—A perfect example on which two oblique spalls, one on each side, form the working edge. 4 cm. long.

(5) *Concave*:—Concave spall opposed to concave spall. Three examples are on narrow blades, and the burinate edge is formed by one spall. One (Fig. 62) is a double, and has the burinate edge at one end formed against a flat surface. 4·5–6 cm. long.

B. *Scaled.*

(1) *Bevel-scaled*:—Oblique line of scales opposed to vertical spall. One (Fig. 63), 3 cm. long, is formed by one spall. The other one (Fig. 64), 4 cm. long, is formed by

one spall also, and is a double, with several shortened spalls forming the edge at the other end.

(5) *Concave-scaled*:—Concave line of scales opposed to vertical spall (Fig. 65). A series of seven specimens 3–5 cm. long. Six are formed by one, and one by two spalls. The spall runs the full length of the face on two, and ends in a jag-like ledge on the other five. The concaves are shallow on the majority and are 1–1·5 cm. wide. Two are nuclei utilized for burinate purposes.

(6) *Rostrate-scaled*:—Vertical line of scales opposed to convex spall. The only specimen (Fig. 69) is a particularly fine example 4 cm. long. It has a shallow concave 1 cm. wide against which the spall has been knapped.

(8) *Counter-scaled*:—Scale opposed to scale. One (Fig. 68), 3 cm. long, is trimmed on its lateral and end margins, and the burinate edge is formed on the corner between them. The other one (Fig. 67) is 6·5 cm. long, and on one surface two spalls have been removed in addition to the counter-scaling.

There are in addition four utilized burinates, two spalled and two scaled, 2–4·5 cm. long.

Cutting edge.

There is a small number of knives from Singleton in comparison with south coast stations (McCarthy, 1943, 144), but the cutting edges on the *elouera*, *bondi* points, and other implements are to be noted.

Among the knives, eighteen are blades, and twelve are pointed. Nine have faceted butts, and five are asymmetrical segments with crust backs. Sixteen are less than 3 cm., the balance up to 9 cm. long.

Among those with a serrated edge (Fig. 34), nineteen are lateral, with their longest margins serrated, seven are end, one side and end, and three double side and end. One of the latter is pointed, and another (Fig. 36), which is rectangular, is very finely and carefully toothed right round its periphery, the trimming being done from the outer face. On five the serrated edge is saw-like, and tiny squills have been removed from both facets of the edge. One (Fig. 39) is an elongate-oval blade, 8 cm. long, with a crust outer surface, and a steep-faced concave serrated edge. Another one, 6 cm. long, has a notched serrated lateral margin, steeply worked. Four have faceted butts, and five are asymmetrical segments with crust backs.

Fabricators.

Only eleven specimens were collected, even though a careful search was made for them, and it is difficult to understand why they are so scarce in this industry. It is apparent that they were used for a purpose of greater importance, or of a commoner nature, on the south coast of New South Wales where they occur in comparatively large numbers (McCarthy, 1943, 132, 145), than in the Singleton district. Four bear one trimmed lateral margin, and one of these has a rounded nose on a corner, in addition to the fabricator edge. Two have faceted butts. Five are of the punch variety. One, with a faceted butt, has a gouge-shaped fabricator edge at the distal end. One is made of quartz. One (Fig. 37) has two concave fabricator edges separated by a short straight edge of the same type.

An unusual specimen is a large crescentic flake of chert with a faceted butt. Heavy trimming, more in the nature of fabricator use, extends around one edge of the curved lateral margin for one-third of its length, and along the balance of this margin along the other edge. The chord is partly serrated. 9 cm. long.

V. Bondi Points.

The series conforms in all respects to that of the south coast of New South Wales (McCarthy, 1943, 145–49, figs. 37–69). Narrow blades predominate in comparison with the broad and rudder forms.

Conformation.—Finished points with triangular transverse section are more numerous than those with trapezoidal section. Curved blades are poorly represented,

perhaps because of the homogeneous and easily worked materials. The butt end is up to 2 cm. wide. Points trimmed on the left margin, when the inner face is downwards, are more numerous than those trimmed on the right margin.

Method of trimming.—Study of the Singleton series has revealed additional evidence in regard to the manner in which the points were made. McCarthy (1943, 147) pointed

Figs. 40-70.—40-48, Concave scrapers. 38, 49-56, Nosed flakes and blades. 57-60, Piercers. 61-70, Burinates. (Two-thirds natural size.)

out that the trimming was begun at the distal or point end on the inner edge (on the majority), or on both edges. The butt was either plain or faceted, or on a minority it was trimmed, thus leaving a section of plain edge along the margin. The usual practice then was to extend the trimming along the inner edge to the plain or faceted butt, and, finally, to trim the butt to a rounded shape to complete the point. Thus were produced two varieties: (*a*) a completely trimmed single-edged point, and (*b*) a point trimmed completely along the inner edge, and at the distal end on the outer edge also. Finally, the trimming on the (*b*) variety was completed along the outer edge and round the butt to make a completely trimmed double-edged point. As shown by the table, plain and faceted butts were often left untrimmed. The faceted butt may be wedge or trapezoid in shape. The well marked varieties of *bondi* points produced in the above manner were probably all used, although some constitute stages in the manufacture of the ideal or standard forms (McCarthy, 1943, 148, figs. 49–51). Exceptions to the above procedure in trimming are very few, one being occasional points trimmed at the butt end only.

Partly trimmed.—As shown in the table, all varieties are represented, but (*b*), (*f*) and (*g*) are scarce in the industry. Two specimens are trimmed at the butt end only. The series includes eighteen broad blades, 1·5–2 cm. wide, and up to 3·5 cm. long, nine of which are trimmed on one edge only. The rudder form is fairly common. One exceptional specimen has a trimmed butt, quite straight and at right angles to the margins, is 1·5 cm. wide, has an oblique shallow concave edge 2·25 cm. long, and is trimmed partly down the chord.

One edge trimmed (Figs. 84–92).—The series ranges from tiny narrow to broad blades 1·5 cm. long, to elongate narrow and broad blades 7·5 cm. long. There is only one specimen of the maximum length, the margin of which is lightly trimmed (Fig. 84), and it constitutes the longest *bondi* point yet recorded. Narrow blades predominate in this group. The majority have a convex and neatly trimmed margin, and a number bear humps not flattened out in trimming. One (Fig. 88), 1·75 cm. wide and 4·25 cm. long, has a trimmed nose on the corner of its butt and two tiny triangular projections along the thick margin. One (Fig. 92) has a nose in the middle of its trimmed margin. The trimming extends round the butt to the chord edge on a few specimens (Fig. 89). One has three small concaves round its butt end, and several (Figs. 86–87) have concave butts.

Two edges trimmed (Figs. 93–97).—There are many beautifully fashioned points in this group, on which the thick margin is flattened or rendered slightly convex by the trimming, so that they are very neatly backed. On the majority the outline of the trimmed margin is from straight to convex. One is of quartz and is 2·75 cm. long. Three have a convex distal end and a prominent point useful for piercing. The longest specimen is figured (Fig. 95), and it is the largest example of the type yet recorded. On many specimens in this group the butt is faceted on the outer edge and trimmed on the inner edge. The trimming extends round the butt to the chord edge on some specimens. The series ranges from 1·25 to 6·5 cm. long.

Two margins trimmed.—Fourteen specimens bear partial trimming on the chord, but none for its full length. One (Fig. 98) is a piece of very fine and hard chert trimmed along both lateral margins; the distal end is an oblique edge, 0·25 cm. long and lightly squilled. The butt bears a shallow concave on one side, a curved trimmed edge extends half-way across to where a piece has been broken off, and this concave edge is lightly trimmed. It is, in general terms, a bilateral symmetrical point, 3 cm. long, 1·75 cm. wide at the butt.

Three edges trimmed.—Fifteen specimens bear partial trimming on the chord in addition to the trimming of the two edges on the thick margin or back, but only one is trimmed along the full length of the chord.

Butt.—The butt is trimmed on the majority, as shown in the table, but attention is drawn to the difficulty of distinguishing faceted butts on the double-edge trimmed points on which the faceting is often effaced in the shaping of the butt; the faceted butt is thus commoner in this group than the table indicates.

Several very long points have a trimmed straight-edged butt, steep-faced, and at right angles to the margins. One has a semi-concave butt, two have shaped butts in the form of a nose, and the fluted butt of triangular shape (McCarthy, 1943, fig. 59) is well represented. Among the single-edged trimmed series five have transverse right-angled butts (Fig. 89). The pointed butt is common, there being sixty examples (Figs. 85–86).

Thin margin use.—The use of this margin ranges from primary squilling due to knife use to a saw-like edge, and trimming or scraper use which includes tiny concaves. One broken point has a trimmed nose on the corner of this margin.

Piercer use.—Trimming on the chord at the distal end in addition to that on the thick margin is present on twelve specimens only. The fact that so few *bondi* points are trimmed in this manner, both at Singleton and on the south coast of New South Wales, indicates that it was done for a special purpose, and was not merely intended to strengthen the point. The most probable use would be for puncturing the skin in connection with the letting of blood during ceremonies.

Sizes.—The following is an analysis of the lengths of the complete points, the balance lacking the distal end: 0–2 cm., 60; 2–3 cm., 157; 3–4 cm., 71; 4–5 cm., 41; 5–6 cm., 10; 6–7 cm., 4; 7–8 cm., 2. Those between 2 and 3 cm. are in the majority, and those less than 3 cm. definitely predominate, as on the south coast of New South Wales (McCarthy, 1943, 133, 149).

A large number of broken points were found on the surface, damaged by the cattle grazing over the paddocks; one of us (F.A.D.) has dug out large numbers of complete points, but has not found any broken ones in the deposit.

VI. Geometrical Microliths.

The geometrical microliths, comprising 245 specimens, constitute a more important group in this industry than on any of the south coast stations, where the highest total of sixty-six was for North Cronulla (McCarthy, 1943, 133). In addition, a total of 163 normal flake and blade implements, and 217 *bondi* points (including 14 of the rudder variety and 33 oblique trimmed blades) are less than 3 cm. long. Most of the geometrical microliths are well made, with evenly trimmed margins, and although irregular and humpy trimming occurs, the series is well developed. The pieces are usually trimmed on the inner edge of the margin, and the trimming often extends to the other edge, as on the *bondi* points.

Conformation.—They are made from bladelets of either trapezoid or triangular transverse section broader and shorter on the average than those used for *bondi* points.

Trapezoid.—The type forms the most numerous series in the industry. There are two varieties, distinguished by the trimmed or untrimmed short parallel lateral margin. In both varieties are four main shapes, as follow: (*a*) elongate, including both symmetrical and asymmetrical forms; (*b*) medium, a symmetrical form in which the short parallel lateral margin is often the same length as the trimmed end margins; (*c*) short, including both symmetrical and asymmetrical forms, often broader than long; (*d*) one trimmed end margin is at right angles to the lateral margins. The proportions vary from elongate and narrow to short and broad, and a minority are as broad as, or broader than, their length. The (*a*) variety predominates, the (*b*) variety being scarcer than (*c*) and (*d*).

There are sixty-six specimens (Figs. 99–105) with the shorter parallel margin untrimmed. One exceptional example (Fig. 105) is 5 cm. long and 2 cm. wide, but has both pointed ends missing. There are four of the (*d*) variety. 1–3·5 cm. long.

There are fifty (Figs. 106–112) with the shorter parallel margin trimmed. The asymmetrical form is in the majority, and there are very few specimens of the symmetrical type. Nine have the shorter parallel margin defined by a sharp-edged peak (Fig. 108) at one or both ends. On two the two oblique end margins are concave (Fig. 110), giving them a tanged shape. 1–2·75 cm. long.

Segment (Figs. 113–120).—Most of the specimens are pointed at each end, but several are rounded and blunt. They are longer on the average than the other

Figs. 71-135.—71-74, Cores. 75, Nosed block. 76, Semi-discoidal block. 77, Biface discoid core implement. 78-82, Oblique trimmed blades. 83, Abrupt trimmed blade. 84-97, *Bondi* points. 98, Point trimmed on two margins. 99-112, Trapezoids. 113-20, Segments. 121, 123, Equilaterals. 122, 124-25, 129, Scalenes. 126, Isosceles. 127-28, Hat-shaped. 130-35, Special pieces. (Two-thirds natural size.)

geometrical microliths. In shape they vary from long and narrow to short and broad, and some are semi-circular. The chord is straight on all but one, the only crescent in the series. Two have a concave near one end of the chord (Fig. 115). One has two trimmed edges on the butt, which is faceted, and its chord is heavily worked, especially where it joins the edge of the butt. 1·75–4 cm. long, and 0·75–2 cm. wide.

Scalene (Figs. 122, 124–25, 129).—The junction of the two trimmed margins consists of a peak on one edge, or a sharp ridge extending from inner to outer face; this area on a minority is rounded. The series vary from elongate and narrow to short and broad forms. The most remarkable microlith (Fig. 124) in the collection is of the bracket type; its slightly convex trimmed margins joined by a prominent peak, and it is very carefully fashioned. 1–3 cm. long, three being 1 cm. only.

Equilateral (Figs. 121, 123).—A uniform series in which the two trimmed margins meet, on all but one specimen which is rounded, in a peak or ridge from inner to outer face. All are less than 1·5 cm. long.

Hat-shaped (Figs. 127–28).—Two specimens only, one of which is twice as wide as it is long, being 0·75 cm. long and 1·5 cm. wide.

Isosceles (Fig. 126).—Three are very narrow, only 0·7 cm. wide, in relation to their length, and seven are 1–1·5 cm. wide. One has a deep concave trimmed edge 1 cm. wide on its chord margin. One has a trimmed oblique end. 1·5–2·5 cm. long.

Oblique trimmed blades (Fig. 79).—The thirty-three examples are included in the total of *bondi* points, but as they appear to be distinctive and not intended to be made into points, they are included here. They are 1·5–3 cm. long, and up to 2 cm. wide. The trimmed oblique edge may be concave, straight or convex. Those more than 3 cm. long are included with the distal end scrapers.

Discoids are not represented.

End or thumbnail (Figs. 25–26).—There are only twenty-two distal end scrapers in the normal flake and blade group less than 3 cm. long, and of these five are duckbills. The majority are flattened, but some are high-crowned.

Micro-burin.—An example (Fig. 66) of the stigmate type (Campbell and Noone, 1943, 294, figs. 37–41), 2 cm. long and 0·75 cm. wide. It has several trimmed concave edges on the same margin as the stigmate.

Special pieces.—One (Fig. 132) is a symmetrical piece 2 cm. long, with a pronounced shoulder on one margin. One (Fig. 130) is a tiny piece 1·5 cm. long, with a convex-edged nose, and two pointed projections on its margin which is trimmed all round. One (Fig. 134) is a pointed oblique trimmed blade, trimmed on both margins of the point, with a straight faceted butt trimmed on its inner edge; it is 2·5 cm. long and 1·5 cm. wide.

One (Fig. 131) is a miniature blade 2 cm. long with a concave and nose on one corner. One (Fig. 135) is an *elouera*-like piece 2·5 cm. long, trimmed on one edge of the thick margin and butt-end, and on the distal end are two sharp piercer-like projections and a rounded nose separated by concaves. One (Fig. 133) is a rounded piece 2 cm. long, with a pointed crown on its upper surface, a concave and a piercer on the margin.

Sizes.—An analysis of the lengths of the geometrical microliths, with the exception of the oblique trimmed blades included with the *bondi* points, is as follows: 0–1 cm., 6; 1–2 cm., 157; 2–3 cm., 63; 3–4 cm., 13 (nine segments and one trapezoid); 4–5 cm., 4 (two segments and two trapezoids).

VII. Glass Implements.

The aborigines are known to have used glass obtained from the white man in various parts of Australia, especially in the Kimberley district. Backhouse (1843, 433) illustrated a death-spear armed with a single row of glass chips that he saw a native carrying near the Cambewarra Mountain, south coast of New South Wales. A large series of glass implements was collected at Singleton, the glass varying from 0·5 to 1 cm. in thickness, and comprising green, brown, blue, amber and white shades of colour. Patches of broken bottles, among which are the implements, were found in isolated localities, especially beside the railway line, river bank, the branch road through

Gowrie, near tree stumps, and along the margin of the terrace. None appeared to be embedded with the stone implements, nor have we dug them out from under the surface, but some pieces were stuck in the surface of the clay as a result of rain softening the ground. It should be pointed out that basic Australian stone flake and blade types are reproduced in the glass and other materials which are known to have been used in the Singleton district by the aborigines after contact with the early settlers. The fact that concave and nosed tools are so common in glass indicates that the most recent natives used much the same kinds of knapped implements as their terrace ancestors. No *bondi* points or geometrical microliths in glass were found. The series comprises side, end, concave and nosed scrapers, and piercers, a description of which is as follows:

Side.—Both straight and convex edges are well represented, and the nondescript fragments of glass used have from one to three trimmed margins, comprising side, side and end, double side, double side and end scrapers. The trimming is from either the concave or convex surface of the glass. One has two trimmed margins at right angles to each other, the corner where they meet being suitable for piercing work. Many of these specimens, and other pieces showing no signs of use, no doubt served as knives. 2–7 cm. long.

End.—The end of an elongate, narrow piece of glass is trimmed, and this restricted working edge varies from straight to convex. Two are trimmed on the outer edge of one end, the spall-scars extending down the convex surface as though for use in the same manner as a plane. One of the nosed scrapers has the same type of edge. 2–6 cm. long.

Concave.—A splendid series of examples, well used and heavily chipped. The concaves are 0·5–2·5 cm. wide, and up to 1 cm. deep. There are as many as three on the one piece of glass, and pairs are common. 2·5–6·5 cm. long.

Nosed.—Twelve have broad rounded noses, and five have narrow noses. The noses have the usual pairs of concaves bounding them, and on one lacking them the nose is on the end. Four have the nose on a corner, and three on an end. 2·5–6 cm. long.

Piercers.—The projections are narrow and carefully trimmed, with a concave on each side, and differ from the nosed type only in the sharply pointed and prepared piercer. There is one piercer on each specimen only, four at the end, three on the corner, and one on a lateral margin. One small example, 3 cm. long, is trimmed all round; it is elongate hour-glass in shape, with two small rounded noses worked from the concave surface of the glass on the same margin as the piercer, and a deep concave working edge worked from the convex surface on the opposite margin.

Other materials.—A number of fragments of crockery and insulator appear to have been used as scrapers, and are 2·5–3 cm. long. A piece of grey roof-slate, 10 cm. long, irregular trapezoid in shape, has its longest margin serrated for 7 cm., the serrations being small and close together.

Affinities.

The Singleton material belongs to the *elouera* industry, and agrees very closely in composition with the south coast stations, especially north Cronulla (McCarthy, 1943). The *tula* adze-flake, symmetrical point, and thirty *arapia*-like normal flake and blade implements and blocks are the only similarities with the industries of the interior, but they are considered to be fortuitous and of no cultural significance. The abundance of geometrical microliths supports the contention of McCarthy (1943, 151) that the *elouera* industry is a variant of the microlithic or *bondi* culture.

Miss L. Hall's study (1928) showed that all elements of the *elouera* industry excepting the geometrical microliths occur at Morna Point and Anna Bay, where grey chert and porphyry are the materials used. The industry is found throughout the Newcastle district, at the mouth of the Hunter River, and although the Australian Museum possesses a few geometrical microliths from this area, they appear to be scarce; grey chert is the principal material. The Singleton phase of the industry is found at Bulga, some fifteen miles to the south on Cockfighter Creek, where one of us (F.A.D.) has collected the implements on eroded patches of soil similar to the Singleton stations. It would be interesting to know whether the industry occurs on the terrace both lower

down and higher up the valley than Singleton, and also along the Goulburn and other tributaries wherever the terrace exists.

A matter of some importance is that both mortars and edge-ground axes are practically absent at Singleton—none of the former have been collected, and only one edge-ground blade which was found about half a mile from the main collecting site at Gowrie. One of us (F.A.D.) has suggested that the absence of mortars may be accounted for by the lack of seed and nut foods at Singleton, because mortars are found in association with the Kurrajong tree and the *Macrozamia* palm, on the slopes of the sandstone ranges near Bulga, and are used in the preparation of their seeds for food. The edge-ground axes present a different problem. They are ploughed up at Bulga, Belford, Milbrodale, and Maitland, and axe-grinding grooves *in situ* occur in the bed of Leconfield Creek, near Greta (Enright, 1936, 23) and at Bulga. These localities are all within thirty miles of Singleton, and the contention might be raised that they were axe-making centres because suitable pebbles and grinding stone were available, and that Singleton was a knapping site only; such an assertion, however, fails to explain why axes are not found in the latter district at all. Had they been in use by the natives who roamed over the alluvial flats, now under cultivation and used for dairying purposes, examples would most probably have been found. In the opinion of old residents near Singleton, the flood depositions of the Hunter River since the days of the aborigines, about one hundred years ago, have not been sufficient to bury axes too deeply for them to be turned up by the plough, and the only floods that appear to have risen to this level are those of 1897 and 1929. In addition, we could expect to find axes embedded in the terrace in association with the knapped implements or to be eroded from it had they been made or used by the same people. Thus a reasonable conclusion to reach appears to be that the knapped implements herein described are not associated with edge-ground axes.

Fawcett (1898, 153, 180) stated that fifty years previously, in about 1850, the weapons and implements used by the Wonnah-ruahs consisted of the ordinary spear, multi-pronged fishing spear, spear-thrower, clubs, shield, returning and non-returning boomerangs, tomahawks or hatchets made of a rudely sharpened stone of a hard dark colour, which was first chipped out and then ground to an edge, and fitted to a handle, knives made of flint used for cutting up meat, chips of flint or shells used in skinning animals, yam-sticks, bags made of plaited swamp-grass, nets, wooden bowls up to three feet long, and bark canoes. Their clothing consisted of cloaks made of opossum skins sewn together, a girdle, and *Nautilus* shell necklet. No indication is given of whether or not the author actually saw these natives with hafted stone axes, and using the flakes, or whether he surmised that they did. There is every reason to believe, therefore, that the natives whom the first white settlers and explorers met had an axe culture and used shells.

Only one *hache-courte*, or one end of a *sumatra*-type uniface pebble implement, is indicative of any *Kartan* cultural influence at Singleton, but implements of this group occur in abundance at Bulga. The uniface pebble implements at Singleton demonstrate an adaptation of the technique to local materials.

No other stone culture has been found near Singleton. It has been shown that axes are lacking, and one of us (F.A.D.) has searched extensively over the flats, but has not come across any other artefacts. The possibility must not be overlooked that the natives merely hunted in the area and camped elsewhere, but this is improbable in view of the game and fish available. Fawcett (1898, 152) stated that the Wonnah-ruah tribe consisted of between five and six hundred natives in a tribal district which included all the country drained by the Hunter River and its tributaries. Mr. W. J. Enright has informed us that the Wonnah-ruah group was a horde of the Kamilaroi tribe. Old residents of Singleton state that between fifty and sixty years ago they saw up to three hundred natives lined up in the town for food and blankets, but they came from many parts of the surrounding country; they camped regularly on various parts of Gowrie Station, according to Mr. White, who was born there and whose father was interested

in their welfare. They used glass, which they obtained from the residents, for implements.

There is no record of the use of stone barbs, such as *bondi* points or geometrical microliths, on the spears.

In the light of the above evidence, let us consider the antiquity of the industry. Three possibilities present themselves, as follow: (*a*) They were made by natives who lived on the terrace when it extended right across the valley. (*b*) They were made at some remote date subsequent to the formation of the present alluvial flats. (*c*) They were made by the people who were living in the area at the time of white settlement.

It might be mentioned that microliths are mesolithic in age in many parts of the world, but their use extends well into the neolithic and even into the bronze ages in some places. In Ceylon, N. A. and H. V. V. Noone (1940) found them on the surface of knolls and rises along grassy ridges, on the slopes of which were larger implements, and some of them were embedded to a depth of two feet, but there was nothing to indicate their antiquity. Campbell and Noone (1943, 303), from their study of South Australian microliths, reached the conclusion that while they are evidence of an extinct culture, there is no reason why their use did not survive till recent times.

Although the implements are embedded to a depth of six inches in the terrace at Singleton, the shallow layer covering them could have been caused by wind-blown dust lodging in the grass and constantly building up a greater thickness of soil over them. At present rain-water is eroding the plateau. At New Freagh there is a layer of sand covering part of the workshop.

In regard to (*a*), the extensive distribution of the implements on the terrace on both sides of the river, and their limitation to the terrace, form the most important evidence in support of their having been made by natives who lived on the terrace when it extended right across the valley. David (1907) stated that, "To the epoch of this maximum subsidence, when the raised beaches were formed, belong, perhaps, the high level alluvials, containing, near Branxton, the remains of the extinct elephantine marsupial *Nototherium*" (p. 340); and, "The highest level alluvials are of two types: (1) red sandy soils and ancient flood loams passing downwards into grittier material, and (2) coarser river gravels, in which jasper pebbles are very numerous and conspicuous . . . of considerable geological antiquity, as they belong to an epoch when the Hunter River was flowing at an altitude of one hundred feet above that of its present channel; obviously many thousands of years would be needed for the deepening of so wide a valley as that of the Hunter by as much as one hundred feet" (p. 288).

(*b*) It appears that the makers of the implements had access to the layer of pebbles at the base of the terrace, at Gowrie at least, and this factor is an important one in support of the conclusion that they were made subsequent to the formation of the alluvial flats. If this is so, the terrace stone-workers preferred to live on the high levels, as scattered fireplaces were noted among the implements, than on the river banks and flats. In any case, they carried the pebbles to the top of the terrace to make their implements. It must be remembered, also, that they are not associated with edge-ground axes, which were used by the most recent natives inhabiting the Hunter valley.

(*c*) The fact that the *elouera* industry occurs on what are commonly regarded as the most recent kitchen-middens in the Newcastle district and south coast areas indicates that it survived there till the coming of the white man, and this view is supported by its association with edge-ground implements, bone and shell tools, all of which are lacking at Singleton. The glass and crockery tools are obviously the product of the most recent aborigines, who also smoked clay-pipes, and although the nosed and concave scrapers in glass reproduce two types important in the terrace stone industry, it must not be forgotten that *bondi* points and geometrical microliths in glass have not been found, and there are no technical difficulties in their manufacture in this material.

The above evidence appears to indicate that the terrace implements form a pre-axe industry at Singleton, which has survived, minus the geometrical microliths, in other parts of the Hunter valley until the coming of the white man. It is possible that it is the oldest culture in the valley, but further information is required before the antiquity

of man in this area can be decided. Distributional data from terrace localities elsewhere in the valley will enable us to decide whether the industry occurs only at this level. Browne (1924) mentioned a similar terrace at Wingen, fifty-seven miles up the valley from Singleton.

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THE GENUS *CONOCARDIUM* FROM AUSTRALIAN PALAEOZOIC ROCKS.

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(Plates xiii–xiv.)

Introduction.

This paper deals with the known species of *Conocardium* from Palaeozoic rocks in Australia. Reference is made to the rather limited records of the genus in literature, and new species are described from the Lower Middle Devonian (Murrumbidgee Series) of New South Wales, from the Upper Middle Devonian (Atrypa limestone) of Western Australia, and from the Permian of New South Wales and Queensland.

The material examined is in the collection of the Australian Museum, with the exception of three specimens, described as *Conocardium gogoense*, sp. nov., from the collection of the University of Western Australia. I am indebted to Dr. Curt Teichert for the opportunity of describing this interesting species.

The known geological range of the genus in Australia extends from the Silurian to the Upper Permian.

The genus *Conocardium* embraces one of the early highly specialized types of shell and was first recorded from Permian rocks in Australia by McCoy (1847, p. 300). Opinion is divided regarding the position of the animal within the shell and the correct orientation is still a subject of discussion. Some workers in this group consider the short truncated end of the shell to be anterior, while others are certain it should be considered the posterior end.

Tryon (1884, p. 195), comparing the shell with *Adacna*, concluded that the conical and gaping end was anterior, the aperture being for the passage of the foot and the function of the long tube or rostrum being siphonal. This view, held by a number of authors, was elaborated by Hind (1900, pp. 452–453) who, after a close examination of the internal characters of a perfect specimen of *Conocardium herculeum*, brought forward several reasons in support of it. He considered the external ligament of *Conocardium* to be restricted, occupying a depression between the umbones and the long rostrum. He remarks: "This surely cannot be placed anterior to the umbones." Other authors, however, are of the opinion that the ligament is amphidetic or paravincular—types one would rather expect in a shell of this type. Hind also states that in bivalves the anterior adductor scar is usually the deeper and better marked, and in many genera, as in *Conocardium*, is bounded behind by a ridge of shell. In *Cucullaea* and other genera, however, we find the exact opposite, the posterior adductor scar being well defined and with a strongly developed ridge.

The pallial line in *Conocardium* is simple and the assumption that it is a siphonate form appears to be attributed to the gape, the presence of the elongated rostrum or analogies with other siphonate genera which have no pallial sinus. These are exceptional, and as a general rule siphonate forms are always recognized by the presence of a pallial sinus. This fact raises the question: what definite evidence have we that *Conocardium* is a siphonate genus?

Hind is of the opinion that the gaping aperture was used for the extrusion of the foot and with this I agree. He states, however, that the foot would be unlikely to protrude over the prominent or sharp interlocking teeth of the valve. In many genera this is exactly what occurs, a case in point being *Cardium*, in which the foot protrudes over much heavier teeth than are present in *Conocardium*.

After a study of the evidence in favour of the truncated end of the shell being posterior, and after several interesting discussions with Mr. Tom Iredale, Conchologist

at the Australian Museum, on the behaviour of recent shells, I conclude this view should be accepted with a great deal of reservation. Any suggestion that the tubular process or rostrum was used for the passage of siphons appears untenable, the extreme length and small diameter of the tube being strong evidence against it. No reasonable suggestion can be put forward as to the function of the rostrum, unless it was for some respiratory purpose. Certainly it was not for a byssus, as the shell was obviously a mobile sand-burrower and not a sedentary byssiferous type.

The general appearance of *Conocardium* affords the best evidence regarding the orientation of its shell. The winged, conical and gaping end, through which the foot protruded, is obviously the burrowing end and when the shell was at rest would remain buried in the sand or mud. It is impossible to visualize the blunt, truncated end being used for this purpose. Making analogies with other burrowing genera, it is found in almost every case that the posterior end of the shell is used for burrowing and is developed structurally towards that purpose.

For the present, therefore, I am following the authors who consider the truncate end, provided with a tubular prolongation, as the anterior portion.

Systematic Position of the Genus.

The family Conocardiidae has been adopted almost universally to receive the single genus *Conocardium*. The systematic position of the family is still very much in doubt. In dealing with specialized or degenerate genera it is difficult and often misleading to arrive at definite conclusions by analogies with other bivalve groups. They are usually a law unto themselves. Hind rightly stated that it is difficult, if not impossible, to assign the family to a correct systematic position.

Historical Notes on the Genus in Australia.

McCoy (1847, p. 300) described and figured a shell as *Pleurorhynchus australis* from Permian rocks, stating the species was "not uncommon of larger size in the sandy schists of Wollongong, New South Wales". Dana (1849, p. 701) recorded the same species from Glendon, but referred it to the genus *Cardium*. He wrongly suspected that McCoy's specimen did not come from Wollongong but was collected at Glendon. Dana also described and figured one end of a shell as *Cardium ferox*. Etheridge (1881, p. 250) thought this may be another species of *Conocardium*, but an analysis of Dana's description reveals that the large size of the shell, the thickness of the valves, and the character of the muscle scars preclude any reference to *Conocardium*.

De Koninck (1877, p. 109) recorded *Conocardium sowerbyi* from "the black argillaceous limestone of the Yass District" which he rightly considered to be Devonian in age. He also (1877, p. 146) recorded *Conocardium australe*? McCoy, from a railway cutting between Maitland and Stony Creek, an horizon almost certain to be the Branxton Stage of the Upper Marine Series. De Koninck was not confident his shell was identical with McCoy's species, though his description reveals few points of dissimilarity. The specimen was not figured, and as De Koninck's type material was destroyed in the Garden Palace fire of 1882, the true identity of this shell must remain doubtful.

Etheridge (1881, p. 250) described a single specimen as *Conocardium*, sp. indet., from the Murrumbidgee Series, Lower Middle Devonian, at Bungaralaby, Lake Bathurst, near Goulburn, New South Wales. This shell is considered to be identical with *Conocardium sowerbyi* De Koninck.

Two species, *Conocardium bellulum* and *C. costatum*, were described by Creswell (1893, p. 43) from the Lilydale limestone in Victoria. The descriptions are very limited, but fortunately the figures are good. The Lilydale limestone, previously considered Upper Silurian in age, is now known to be Middle Devonian (Hill, 1939, p. 219).

Chapman (1908, p. 45) recorded both the Victorian species with additional localities.

The only Queensland record of the genus is that of Etheridge (1892, p. 278), who described a shell from the Gympie Series as *Conocardium australe* McCoy. Later (1902, page 68) he stated: "The shell I formerly figured from the Permo-Carboniferous of Queensland as *C. australe* I now know is not that species; it is separated therefrom by

the characters of its anterior end." The Queensland shell is distinct from the typical *C. australe* and has been named *Conocardium gympiense*, sp. nov.

Etheridge (1902, p. 68) described *Conocardium australe* from the Upper Marine Series at Hartley, New South Wales. This shell is an inflated type now renamed *Conocardium robustum*, sp. nov.

Dun (1907, p. 265) described two specimens from the Upper Silurian rocks at Oakey Creek, near Molong, New South Wales, as *Conocardium davidis*. Another specimen from the Upper Silurian Lower Limestone bed of the Bowning Series at Limestone Creek near Silverdale, was exhibited by Mitchell (1906, p. 262) at a meeting of the Linnean Society of New South Wales. The shell was of small size, not more than half an inch along the hinge-line; unfortunately the shell has been mislaid and its occurrence must remain solely as a record.

Walkom (1913, p. 137) recorded *Conocardium australe* in a list of fossils from the upper part of the Branxton Stage, and also listed it as occurring in the Muree Stage.

The genus *Conocardium* has been recorded from several localities in Western Australia. Etheridge (1907, p. 33) recorded a small shell, differing from *C. australe* McCoy, from Permian beds of the Irwin River district. Teichert (1941, p. 377) records it from the Fossil Cliff limestone. Other records have been listed by Glauert (1910, p. 91) including *Conocardium ? hibernicum* Sowerby, an unlikely species in Australian rocks, from the Kimberley district.

The occurrence of the genus in Carboniferous rocks is restricted to a single specimen from Clarence Town, New South Wales. The specimen is in the collection of the Australian Museum (F.40893) and consists of a small portion of the anterior cordiform area, the anterior ridge, and part of the median region. It differs considerably from other species of the genus, but is too incomplete for description and has been mentioned merely as a record of its occurrence.

A collection of fossils from Muswellbrook, New South Wales, was identified by Dun (1937, p. 155), and included among them was *Conocardium*, sp. nov. This specimen has since been examined and identified as *Conocardium australe* (McCoy).

Following is a list of the known species of *Conocardium* occurring in Australian rocks, showing their stratigraphical distribution.

Species.	Lower Silurian. (Melbournian.)	Upper Silurian. (Yeringian.)	Middle Devonian.	Upper Devonian.	Carboniferous.	Permian.					
						Lochinvar Stage.	Allandale Stage.	Farley Stage.	Branxton Stage.	Muree Stage.	Mulbring Stage.
Conocardium costatum (Creswell)	x ?		x								
,, *bellulum* (Creswell)		x	x								
,, *davidis* Dun. ..		x									
,, sp.[1]		x									
,, *sowerbyi* de Koninck			x								
,, *mundulum*, sp. nov.			x								
,, *abscissum*, sp. nov.			x								
,, *laseroni*, sp. nov. ..			x								
,, sp. indet.[2]			x								
,, *gogoense*, sp. nov. ..				x							
,, *gympiense*, sp. nov.						x					
,, sp. indet.[3]					x						
,, *robustum*, sp. nov.									x		x
,, *australe* (McCoy) ..							x		x	x	x
,, *truncatum*, sp. nov.							x				

[1] Specimen collected by Mitchell (1906, p. 262).

[2] A small portion of a shell from Tarago, New South Wales, denotes the presence of a large undescribed species of *Conocardium* in the Murrumbidgee Series of the lower part of the Middle Devonian. Australian Museum collection (F.40892).

[3] Referred to earlier in this paper. From Clarence Town, New South Wales.

From this table it will be seen that all the species of the genus have an apparent short vertical range. *Conocardium* is by no means a common shell and a good many of the species are represented by single specimens which are, however, well preserved. It is always desirable to have series of specimens in describing new species, but at times even fragmentary material should be utilized if sufficient distinctive characters are present. Only in this way will the palaeontology of any area become known and at the same time collectors stimulated to greater efforts in their search for further specimens.

For the purposes of description in this paper I have followed Barrois and Whidborne in dividing the shell of *Conocardium*, from anterior to posterior, into the following regions: (1) rostrum, with the exception of short basal portions, not preserved on any Australian shells; (2) anterior cordiform slope; (3) anterior keel; (4) median region; (5) median ridge; (6) posterior slope; (7) posterior sinus; (8) conical aliform protuberance.

Description of Species.

Family CONOCARDIIDAE Neumayr.

Genus Conocardium Bronn.

Conocardium costatum (Creswell). (Plate xiii, figs. 1–2.)

1893. *Pleurorhynchus costatus* Creswell, Proc. Roy. Soc. Vict. (N.S.), v, p. 43, pl. lx, fig. 5.

1908. *Conocardium costatum* Chapman, Mem. Nat. Museum, Melbourne, No. 2, p. 45.

The original description of this species is "about half-an-inch long, with nine simple ribs on the anterior part of each valve, and about seventeen on the hinder part".

Chapman did not add to this description, but from Creswell's figures it is clearly seen to be unlike any other species of the genus.

Occurrence.—Cave Hill, Lilydale, Victoria. Chapman doubtfully records a damaged specimen from the Domain Road sewer, Melbourne, from Lower Silurian beds of Melbournian age.

Horizon.—Lower part of the Middle Devonian.

Holotype.—No. 910, National Museum, Melbourne.

Conocardium bellulum (Creswell). (Plate xiii, figs. 3–4.)

1893. *Pleurorhynchus bellulus* Creswell, Proc. Roy. Soc. Vict. (N.S.), v, p. 43, pl. lx, fig. 6.

1908. *Conocardium bellulum* Chapman, Mem. Nat. Museum, Melbourne, No. 2, p. 45.

The original description of this species is as follows: "About one-third of an inch long, with the body of the shell more oblique than the hinge-line, more prettily banded and ribbed than *C. costatum*, the ribs being crossed with striae and the valves having a distinctly fenestrated appearance at the posterior end."

I have not had an opportunity of examining any specimens of the Victorian species, but Creswell's original figures, republished in this paper, show few points of similarity with other species of the genus. Chapman compares this species with *C. dipterum* Salter and *C. cuneus* Conrad sp., var. *nasutum* Hall, species in which the shell is anteriorly broad and abruptly truncated.

Occurrence.—Cave Hill, Lilydale, Victoria; abundant at Deep Creek, a tributary of the Thompson River, 7 miles north of Walhalla, Gippsland, Victoria. Chapman recorded a single specimen from a mudstone at the junction of the Woori Yallock and the Yarra, Melbourne, Victoria.

Horizons.—The geological age of the beds at Walhalla is now thought to be Lower Devonian and not Upper Silurian. Hill and Jones came to this conclusion after an examination of the corals of that area (1940, p. 198). The Cave Hill limestone at Lilydale is now placed in the lower part of the Middle Devonian, so that *Conocardium bellulum* ranges from the Upper Silurian (Yeringian) to the Middle Devonian.

Holotype.—No. 911, National Museum, Melbourne.

Conocardium davidis Dun. (Plate xiii, figs. 5–6.)

1907. *Conocardium davidis* Dun, Records Geol. Survey of N.S.W., viii, 3, p. 268, pl. xl, figs. 6, 6*a*.

The two specimens originally described by Dun are the only ones known of this small Upper Silurian species. The only other reference to the genus from Silurian rocks in New South Wales is that of Mitchell (1906, p. 262) from Silverdale, near Bowning, referred to earlier in this paper.

Conocardium davidis has some points of similarity with *C. mundulum*, but is distinguished by several characters. It is a slightly deeper shell in comparison with the length and is not as oblique. The broad ribs on the median region of both species are similar, but in *C. davidis* they radiate directly towards the ventral margin, whereas in *C. mundulum* they extend obliquely forward and at the base are all anterior to the umbo.

The anterior keel is prominent, broadly rounded and slightly concave. Anterior cordiform area not large, gently concave and smooth, with three to four radiating ribs centrally situated.

The densely crowded, fine growth lines are characteristic, prominent on the conical aliform protuberance, becoming less noticeable on the inflated median region.

Shell gaping at the posterior portion, but not widely.

The dimensions are: Pl. xiii, fig. 5, length 10 mm., height 8 mm., thickness 6 mm.; Pl. xiii, fig. 6, length 9 mm., height 5·5 mm., thickness 4 mm.

The specimen figured by Dun (pl. xl, figs. 6, 6*a*) is the holotype of the species and has been reproduced in this paper on Pl. xiii, fig. 5. The second specimen is figured on Pl. xiii, fig. 6.

Occurrence.—Oakey Creek, Parish Barton, County Ashburnham, New South Wales.

Horizon.—Upper Silurian.

Holotype.—F.40820, Australian Museum, Sydney.

Conocardium mundulum, sp. nov. (Plate xiii, figs. 7–9.)

Description.—Shell small, equivalve, inflated, truncated anteriorly and conically depressed posteriorly. The long tubular rostrum on the truncated surface not preserved.

Umbo prominent, recurved anteriorly. Hinge-line long, straight, slightly arched posteriorly, sunk below the dorsal margin. Anterior margin produced to form the rostrum above, straight but extending forward below and meeting the curved basal margin of the median region at about two-thirds the depth of the shell. Posterior margin oblique, straight and meeting the hinge-margin at an acute angle.

Anterior cordiform slope elongated and narrow; concave between the base of the rostrum and the anterior keel, less so between the anterior margin and the keel. Ornamented by five gradually increasing rounded ribs, of which the outer two are shortened by the anterior keel.

Anterior keel prominent, curved and does not nearly reach the lowest point of the shell. Median region inflated, narrow and convex, ornamented by five coarse, faintly lamellated, sub-angular radiating ribs, separated by interspaces equal to them in width. The ribs originate at the apex of the umbo and radiate forward and downward to the ventral margin so that the base of the last rib is anterior to the umbo. A small fine rib is interpolated between the anterior keel and the first coarse rib.

The posterior slope inclines rapidly from the median region, becoming more or less flattened at the gaping, conical aliform protuberance. The surface is ornamented by at least seventeen radiating ribs, fine on the posterior slope and increasing in size towards the extremity. The interspaces between the ribs are marked by lamellose concentric striae or growth lines.

The dimensions of the holotype are: length 10 mm. (incomplete), height 7 mm., thickness 6 mm.

Observations.—This species is represented by a single specimen which has portion of the posterior gape broken away, but is otherwise excellently preserved. It is very

easily distinguished from other species of the genus by its small size, general form, and the forward trend of the strong ribs on the median region.

Occurrence.—The specimen was collected by Mr. C. F. Laseron from a limestone at Lake Bathurst Railway Station, twenty miles south of Goulburn, New South Wales.

Horizon.—Murrumbidgee Series, lower part of the Middle Devonian.

Holotype.—F.30189, Australian Museum, Sydney.

Conocardium sowerbyi De Koninck. (Plate xiii, figs. 17–18.)

1877. *Conocardium sowerbyi* De Koninck, Foss. Pal. Nouv.-Galles du Sud, pt. 3, p. 109.
1881. *Conocardium*, sp. ind., Etheridge, Journ. Proc. Roy. Soc. of N.S.W., xiv, p. 250, pl., fig. 9.

De Koninck was of the opinion that the two shells he described from a black argillaceous limestone in the Yass district were identical with *Cardium aliforme* (var.) Sowerby (1840, pl. 56, fig. 2) and with *Pleurorhynchus aliforme* Phillips (1841, pl. 17, fig. 51). He placed these two species as synonyms of *Conocardium sowerbyi*, the name applied to the Australian shell.

De Koninck considered that *Cardium aliforme* (var.) Sowerby had been confused with the exclusively Carboniferous species *Conocardium aliforme* Sowerby, which differed from it in a number of essential characters.

This change in nomenclature for the two British Devonian forms has been apparently overlooked by workers on this group, but later Whidborne (1892, p. 27) referred Sowerby's shell to *Conocardium phillipsii* d'Orbigny, and *Pleurorhynchus aliforme* of Phillips to *Conocardium clathratum* d'Orbigny.

The change in synonymy of the British species does not affect the status of *Conocardium sowerbyi* of De Koninck as the description of this species was compiled from the Australian shells and the name is retained for them. Many Australian fossil shells have been identified in the past as British and European species, but it is now generally recognized that the existence of world-wide species must be looked upon with suspicion.

De Koninck did not figure his specimens, and as they were destroyed in the Garden Palace fire of 1882 we must depend on the description to identify further specimens and establish his species.

Several distinguishing features were pointed out by De Koninck; one of the most important is the large number of concentric ribs on the anterior cordiform slope. Over the remainder of the surface the ribs, about twenty in number, are fairly regular and almost all the same thickness, the last few, covering the posterior and gently gaping portion of the shell, being a little less thick and more flattened than the others.

The dimensions are as follows: length 15 mm., height 13 mm., thickness 11 mm.

The single specimen described by Etheridge as *Conocardium*, sp. ind., is considered to be identical with *C. sowerbyi*. The author makes no mention of the pronounced concentric markings, but an additional specimen from a nearby locality shows them distinctly. This specimen from Tarago, New South Wales (Pl. xiii, figs. 17–18), and Etheridge's specimen agree in all essential characters with De Koninck's species from beds of the same age but about sixty miles to the west.

The species is characterized by the ornamentation being composed of regular and uniform radiating ribs. On the alate posterior protuberance, which is swollen and convex, the ribs are slightly more flattened. In between the ribs, twenty-seven in number, concentric markings give the shell a cellular appearance, a feature stressed by De Koninck. The anterior cordiform area is heart-shaped, concave within the angle of the anterior keel, convex in the middle, and produced above to form the rostrum. The rostrum, although broken from the shell, is preserved in the matrix and is 5 mm. in length. In the concavity of the anterior cordiform slope there are six radiating ribs, slightly heavier than the remainder of the ribs, and these follow the curve of the keel. On the convex portion which forms the base of the rostrum the radiating ribs are finer and for the most part have disappeared through weathering, leaving a smooth surface. The numerous concentric striae are very distinct. Anterior keel broad and well defined.

The dimensions are as follows: Neotype, length 10 mm., height 6·5 mm., thickness 6 mm.; specimen from Bungaralaby, length 19 mm., height 14 mm., thickness 14 mm.

As the holotype and co-type of this species were destroyed, the specimen from Tarago, figured in this paper, has been selected as the neotype. It is a small shell, but exhibits very clearly the characters outlined by De Koninck in the original description of *C. sowerbyi*.

Occurrence.—The specimens described by De Koninck were collected in the black argillaceous limestone of the Yass district. A single specimen, described by Etheridge, was collected at Bungaralaby near Lake Bathurst from an horizon which was thought, at that time, to be Carboniferous in age. The neotype was collected at Tarago, a few miles south of Lake Bathurst, New South Wales.

Horizon.—Lower Middle Devonian (Murrumbidgee Series).

Neotype.—F.40891, Australian Museum, Sydney.

Conocardium abscissum, sp. nov. (Plate xiii, fig. 10.)

Description.—Shell small in size, obliquely triangular in outline, as wide as high. Abruptly truncated anteriorly, acutely conical posteriorly.

Median region narrow, rounded and inflated, almost pointed inferiorly and ornamented by five prominent, flattened, radiating ribs originating at the umbo. Each rib possesses a shallow central groove and is almost at right angles to the straight hinge-line, the radiation of the main ribs being very slight. There appears to be no distinct anterior keel, its place being taken by one of the main ribs; on the anterior slope of the median region there is one rib, on the posterior slope three ribs. The interspaces are equal in width to the ribs and are ornamented with very fine and numerous wavy concentric lines.

Inferiorly the median region is bluntly pointed. The posterior margin slopes rapidly from it in a straight line and meets the hinge margin at an acute angle. Posterior slope of the median region steep, forming a shallow sinus at the junction with the compressed, slightly convex and gaping posterior aliform protuberance. Ornamented by 10–12 ribs which originate from the hinge-line near the umbo. These ribs do not nearly attain the thickness of the ribs on the median region.

The dimensions are as follows: height 11 mm., length 10 mm., thickness 7 mm.

Observations.—The only representative of this species is a single incomplete specimen found associated with *C. mundulum* and *C. laseroni*. The truncated, anterior cordiform slopes are obscured by matrix and partly missing, while the extremity of the conical aliform protuberance is also imperfect. The median region and ornamentation are well preserved and show striking differences from other species of the genus. It is a very distinct form, and there is no other species with which it can be confused.

Occurrence.—Collected from a weathered limestone at the Lake Bathurst Railway Station, 20 miles south of Goulburn, New South Wales.

Horizon.—Murrumbidgee Series, lower part of the Middle Devonian.

Holotype.—F.39761, Australian Museum, Sydney.

Conocardium laseroni, sp. nov. (Plate xiii, figs. 11–13.)

Description.—Shell of medium size, obliquely triangular, strongly inflated, longer than high. Beaks prominent, incurved, situated anteriorly. Hinge-line straight for two-thirds its length, sloping downwards posteriorly. Anterior cordiform slope concave, recessed well below the bordering anterior keel, and ornamented by fine ribs which follow the curve of the keel. The keel itself is prominent, strongly curved, and increases in width inferiorly. Rostrum aperture almost centrally situated.

Median region strongly inflated, ornamented by 6–7 coarse ribs with wide interspaces marked with well defined concentric striae. This region is bluntly carinated with steep slopes formed on either side. Viewed anteriorly the slope is as wide as the enclosed cordiform slope and bears three coarse ribs. Posteriorly the slope of the median region is narrower, ornamented by three coarse ribs; a shallow but distinct sinus is formed at its junction with the main posterior slope of the shell. The posterior slope is

separated from the conical aliform protuberance by a well defined shallow sinus; the former is a well rounded, convex area, the latter a smaller and flattened area at the posterior extremity.

The posterior slope is ornamented by eight fine ribs, originating from behind the beak and curving towards the inferior margin, where they increase in width. The flattened aliform portion possesses nine similar ribs which follow the curve of the dorsal margin. The whole surface of the valve is covered with fine, elevated, concentric striae, closely arranged and giving the shell a cancellated appearance.

The dimensions of the shell are: length 15 mm., height 10 mm., thickness 10 mm.

Observations.—This outstanding species of the genus is represented by a single mould of a left valve. It is well preserved, and a prepared cast shows very clearly the ornamentation and general outline of the shell.

Five species of *Conocardium* are found in the Murrumbidgee Series of the Middle Devonian. Three of these, *C. laseroni*, *C. abscissum* and *C. mundulum*, are characterized by possessing coarse ribs on the median region, while *C. sowerbyi* has uniform ribbing over the whole surface of the valves. The present species falls into the first group, but is very easily distinguished by the deeply recessed cordiform slopes and position of the anterior keel.

Occurrence.—The single specimen was collected by Mr. C. F. Laseron from a weathered limestone near the Lake Bathurst Railway Station, 20 miles south from Goulburn, New South Wales. The complete shell which came from the described mould was collected by Mr. C. F. Laseron, but unfortunately was mislaid.

Horizon.—Murrumbidgee Series, lower part of the Middle Devonian.

Holotype.—F.30160, Australian Museum, Sydney.

Conocardium gogoense, sp. nov. (Plate xiii, figs. 14–16.)

Description.—Shell small, sub-angularly ovate, equivalve, with a rounded, slightly flattened anterior portion, and widely gaping, conical, posteriorly.

Valves convex, with the greatest convexity in the median region. Umbo small, slightly incurved. Hinge-line straight, sunk below the rounded superior margins. Well marked lunule, ligament external.

Anterior margin produced to form the rostrum, slightly above the hinge-line, gently curved below. Inferior margin narrow, rounded. Posterior margin oblique, practically straight, meeting the hinge margin at an angle of about 45°.

Anterior keel fairly prominent, not curved, and formed by a fold or thickening of one of the ribs. It is situated in the centre of the median region and reaches to the lowest portion of the shell. The anterior cordiform slope, anterior of the keel, is large and hardly differentiated from the remainder of the valve, and is slightly flattened and concave near the hinge margin. Ornamented by 13–14 close, low rounded ribs originating at the apex of the beak and curving away from the anterior keel.

Median region narrow, ornamented by four coarse ribs with wide interspaces. The posterior slope of the shell is horizontally oblique, convex, ornamented by thirteen ribs, similar in appearance, with interspaces as wide as or wider than the ribs. The conical, aliform protuberance not well defined. Along the gaping inferior margin the radiating ribs continue into the interior of the valve, strengthening them considerably. Shell widely gaping posteriorly.

The dimensions are as follows: holotype, length 8 mm., height 8·5 mm., thickness 6 mm.

Observations.—This interesting Western Australian species is represented by three well preserved and complete specimens. The holotype, of which the measurements are given, is the smallest; the others attain slightly larger proportions, but do not exceed a length or height of 10·5 mm. A large Carboniferous species, *Conocardium hibernicum* Sowerby, has been recorded from the Kimberley area; this form, though the determination is most doubtful, is totally unlike the present species and could not have been confused with it.

The characteristic ornamentation and the anterior keel passing vertically downwards from the apex of the beak and forming a large cordiform area which hardly differs from the remainder of the valve, make it an outstanding and characteristic Australian species. The rostrum is not preserved in its entirety, but in one specimen a good deal of the base remains, revealing a very minute aperture.

Occurrence.—Gogo Station, Kimberley Division, S.S.W. of No. 10 Bore, about one-third of a mile off the limestone escarpment, Western Australia.

Horizon.—Upper Middle Devonian (*Atrypa* limestone).

Holotype.—C.57, University of Western Australia.

Conocardium gympiense, sp. nov.

1892. *Conocardium australe* Etheridge (non McCoy) *in* Jack and Etheridge, Geol. and Pal. Q'ld. and New Guinea, p. 278, pl. 14, fig. 6.

Observations.—Etheridge (1902, p. 68) concluded that the single shell he had described as *C. australe*, from the Gympie beds of Queensland, was not that species. In his original description he stated it was larger than McCoy's figure, but resembled it in outline and figure, except that the two diverging impressed lines on the shorter end of the shell are not visible. Etheridge says: "The difference in the strength of the striae on the portions which would be bounded by these impressed lines, is, however, quite apparent, and as described by McCoy." In 1902, he stated the Queensland shell is not *C. australe*; "it is separated therefrom by the characters of the anterior end".

The specimen described by Etheridge is possibly housed in the collection of the Geological Survey in Brisbane. I have not been able to examine it, so the conclusions arrived at in this paper have been deduced solely from Etheridge's figure. To my knowledge the only other specimen of *Conocardium* known from the Permian of Queensland is a specimen recorded by Reid (1930, p. 74) from the Middle Bowen beds at Logan Downs.

In the Permian beds of New South Wales the species of *Conocardium* show considerable variation in shape and consequently their specific limits are not readily defined. Even so, an examination of Etheridge's figure reveals several distinctions, although it is very similar to *C. australe*. The anterior keel and the median region in the Queensland shell are not as oblique as in *C. australe*. A line drawn from the apex of the umbo to the inferior margin, at right angles to the hinge-line, encloses a portion of the median region between it and the anterior keel. This is very pronounced in the majority of specimens, whereas in the Queensland shell the anterior keel projects to the rear of a similar parallel line and the base of the keel is almost immediately below the umbo. The ornamentation also shows points of distinction. On the posterior conical alate portion of the shell the ribs are much finer and greater in number than on *C. australe*. The posterior inferior margin is also more concave than in *C. australe*. The number of fine ribs on the posterior slope of the Queensland shell is greater than on *C. australe*.

These distinctions are sufficient in my opinion to separate Etheridge's specimen from *C. australe*, and as Etheridge considered them two distinct species, the Queensland shell has been named *C. gympiense*. It is to be hoped that in the near future additional specimens will be collected from Gympie and so prove whether this procedure has been premature or not.

The dimensions of the specimen, taken from Etheridge's figure, are as follows: length 32 mm., height 21 mm.

Occurrence.—Gympie, Queensland.

Horizon.—Gympie Beds, Lower Permian.

Conocardium australe (McCoy). (Plate xiv, figs. 1, 8–9.)

1847. *Pleurorhynchus australis* McCoy, Ann. Mag. Nat. Hist., xx, p. 300, pl. 16, fig. 4.

1849. *Cardium australe* Dana, Report Wilkes U.S. Exploring Exped., x, Geol., p. 701, pl. 18, fig. 2.

1877. *Conocardium australe* De Koninck, Foss. Pal. Nouv.-Galles du Sud, pt. 3, p. 284.

Description.—Shell of medium size, length 26 mm., oblique, truncated anteriorly, conical posteriorly. Umbo prominent, situated anteriorly. Hinge-line elongate, straight.

Anterior margin straight, nearly perpendicular below the base of the rostrum; inferior margin of median region slightly curved, continuing posteriorly, almost straight but obliquely to the hinge-line which it joins at an angle of about 70°.

Anterior cordiform slope flattened, ornamented by at least 20 fine radiating ribs, which are divided into three divisions by two furrows originating at the apex of the umbo. Anterior keel curved, fairly prominent, not reaching the lowest portion of the shell. The median region is narrow, inflated and oblique, ornamented by four to five ribs with wide interspaces. The posterior slope of the valve is inflated and convex, becoming flattened at the conical aliform posterior extremity. A wide, shallow sinus separates the two portions. The convex portion is ornamented by 12–14 fine ribs of uniform size, closely packed, originating from behind the umbo. The flattened extremity, slightly rolled, or convex, possesses nine broad, flattened ribs, with narrow interspaces, which arise from the hinge-margin.

The whole surface is covered with fine concentric lines of growth which give the shell a cancellate appearance.

The dimensions are as follows: Pl. xiv, fig. 9, length 26 mm., height 19 mm., thickness 10 mm.; Pl. xiv, fig. 8, length 31 mm., height 17 mm., thickness 9 mm.; Pl. xiv, fig. 1, length 40 mm., height 32 mm., thickness (approx.) 14 mm.

Observations.—The above description was taken from a plaster cast of the holotype which is housed in the Sedgwick Museum, Cambridge. Etheridge (1902, p. 68) suspected that the shells described by Dana and McCoy did not belong to the same species, because of the following reasons. McCoy in his description stated "the anterior face obliquely sub-truncate, convex, divided into three nearly equal tumid compartments by two impressed furrows from the beak. . . . Anterior face finely striated longitudinally". Dana, on the other hand, states "anterior to the carina, the surface a little concave and finely striate longitudinally".

Etheridge appeared to place too much importance on the concavity or convexity of the cordiform slope. He remarks: "In Dana's figure the anterior end of the shell is so remarkably concave that I am led almost to believe that the authors in question dealt with two distinct species." He stresses this point, although Dana describes the surface as being "a little concave". The convexity of the cordiform slope in McCoy's specimen is not great, in fact it is almost flattened. Furthermore, even though Dana did not mention the presence of the impressed furrows, dividing the ribs into three groups, they are clearly seen on his figure. There is no doubt that Dana's and McCoy's specimens are the same species.

Etheridge (1902, p. 68), in describing a specimen from Hartley, stated it did not possess the arrangement of ribbing on the posterior portion of the shell as laid down by Dana, i.e. "four broad, nine to ten much narrower, and the following again broader". His specimen has been identified as *C. robustum*, a new species from the Upper Marine Series characterized by the anterior portion of the shell being strongly inflated. The ornamentation varies from *C. australe*, but not to any great extent.

The shell doubtfully referred to *C. australe* by De Koninck (1877, p. 146) differs only in size and seems to be a typical specimen of the species.

The specimen figured (Pl. xiv, fig. 1) is a large specimen of *C. australe* from Buchanan, New South Wales. Most of the posterior portion of the valve is missing.

The species, *C. australe*, is an unmistakable one and the only other form with which it can be compared is *C. robustum*. It differs in the anterior portion of the shell not being nearly as inflated as in that species.

It has a geological range from the Allandale Stage in the Lower Marine Series to the Mulbring Stage in the Upper Marine Series.

Occurrence and Horizon.—New South Wales: Lower Marine Series, Allandale Stage: Pokolbin. Upper Marine Series: Wollongong, Berarra, Wyro, near Ulladulla (South

Coast); Mount Vincent, Glendon, Muswellbrook, railway cutting between Maitland and Stony Creek (Hunter Valley); Rylstone.

Holotype.—Sedgwick Museum, Cambridge, England.

Conocardium robustum, sp. nov. (Plate xiv, figs. 2–7, 10.)

1902. *Conocardium australe* Etheridge (non McCoy), Rec. Geol. Survey of N.S.W., vii, 2, p. 68, pl. xviii, figs. 8–9.

Description.—Shell large, oblique, strongly inflated and truncated anteriorly, compressed, conically produced posteriorly. Umbones not prominent, flattened and incurved, widely separated. Hinge-line straight, sunk below superior rounded margins. Anterior margin produced to form the rostrum above, convex below. Inferior margin of the median region curved, and continuing posteriorly in an almost straight line to the hinge margin which it joins at an oblique angle. Anterior keel fairly prominent, curved well forward and does not reach the lowest part of the shell.

Anterior cordiform slope wide, flattened, slightly concave between the apex of the umbo and the base of the rostrum. Ornamented by twenty, closely packed, fine ribs, divided into three unequal areas by two shallow, radiating furrows, which originate at the apex of the umbo.

The median region is very obliquely produced anteriorly, narrow, convex and ornamented by five coarse ribs with wide interspaces. The posterior portion of the shell rapidly decreases from the swollen median region to form a narrow elongated, slightly rounded, extremity, with a wide gape. The posterior slope is ornamented by about 14 fine ribs originating in front of the beak, and followed by five or six coarse ribs with wide interspaces. The ribs are strengthened along the inferior margin, giving it a strongly crenulated appearance.

The surface of the valve is covered with heavy concentric growth lines which give the shell a strongly reticulated appearance. This is not noticeable on weathered internal casts.

The dimensions are as follows: Pl. xiv, figs. 5–7, length 47 mm. (incomplete), height 25 mm., thickness 32 mm.; Pl. xiv, figs 2–4, length 50 mm. (incomplete), height 21 mm., thickness 39 mm.; Pl. xiv, fig. 10, length 33 mm., height 24 mm., thickness 19 mm.

Observations.—In association with *C. australe*, and occurring only in the Upper Marine Series, is this remarkable species with a strongly inflated and oblique anterior cordiform slope. In comparison, the posterior alate protuberance is markedly compressed, narrow and elongated. In most cases the widely gaping posterior extremities have been broken from the valves. A wide lunule is well developed. The anterior inferior surface of the shell is broad, flattened or slightly convex. It is impossible to confuse this species with *C. australe*, the only other species of *Conocardium* with which it can be compared.

The specimen described by Etheridge as *C. australe* from Hartley is a typical example of this species. The holotype was collected from the Upper Marine Series at Gerringong.

Occurrence.—New South Wales: Rylstone, Mount Vincent, Gerringong, Wyro, near Ulladulla, Hartley.

Horizon.—Upper Marine Series, Permian.

Holotype.—F.40916, Australian Museum, Sydney.

Conocardium truncatum, sp. nov. (Plate xiv, fig. 11.)

Description.—Shell cone-shaped; flatly truncated, inflated anteriorly; convex, conical posteriorly. Very inequilateral. The anterior cordiform slope is flat, almost at right angles to the anterior keel. Ornamented with numerous very fine ribs which follow the curve of the keel. The anterior keel practically at right angles to the hinge-line. A median region is not defined, the valve gradually and evenly sloping from the anterior keel to the posterior extremity. Vertically the posterior region is evenly convex. The inferior margin extends obliquely from the anterior keel, the lowest point of the shell, to the straight and long hinge-line, which it meets at an acute angle.

The dimensions are as follows: length 32 mm., height 27 mm., thickness, 20 mm.

Observations.—This species is represented by a single cast of a left valve. The only ornamentation preserved is the fine ribs on the anterior cordiform slope. The shell, however, is so totally unlike any other species of the genus in Australian Permian rocks that it is worthy of specific status, even though the specimen is poorly preserved and the description, as a result, very limited.

The species is distinguished by the flattened anterior cordiform slope, which is at right angles to the hinge-line and to the almost vertical anterior keel which extends to the lowest portion of the valve. The median region, if defined by the ornamentation, does not differ from the rest of the posterior portion, as the surface slopes gradually and evenly from the anterior keel to the posterior extremity.

Occurrence.—Collected by Mr. A. H. Voisey, M.Sc., at "Colraine", Kimbriki, Manning River, northern New South Wales.

Horizon.—Macleay Series (Lower Marine Series), Permian.

Holotype.—F.37827, Australian Museum, Sydney.

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EXPLANATIONS OF PLATES.

Plate XIII.

Conocardium costatum (Creswell).

Fig. 1.—The holotype (after Creswell) showing general outline and ornamentation of the shell.

Fig. 2.—Anterior view of Figure 1, showing cordiform slopes and position of the rostrum.

Conocardium bellulum (Creswell).

Fig. 3.—The holotype (after Creswell) showing anterior cordiform slopes and the almost central position of the rostrum.

Fig. 4.—Side view of Figure 3, showing general outline.

Conocardium davidis Dun.

Fig. 5.—Left valve of the holotype showing outline and ornamentation of the valve. (F.40820.)

Fig. 6.—Left valve showing ornamentation on anterior cordiform slope. (F.40821.)

Conocardium mundulum, sp. nov.

Fig. 7.—Side view of the holotype showing different types of ornamentation and general outline. Posterior extremity missing. (F.30189.)

Fig. 8.—Dorsal view of Figure 7, showing anterior keel and enclosed anterior cordiform slopes.

Fig. 9.—Dorsal view of same specimen showing straight hinge-line and inflation of the anterior portion of the shell.

Conocardium abscissum, sp. nov.

Fig. 10.—Side view of the holotype showing characteristic ornamentation. The anterior cordiform slopes and the posterior extremity are missing. (F.39761.)

Conocardium laseroni, sp. nov.

Fig. 11.—Anterior view of the holotype showing strongly curved anterior keel and recessed cordiform slope.

Fig. 12.—Side view of Figure 11, showing well marked median region and strongly convex posterior slope.

Fig. 13.—Ornamentation on the posterior alate prolongation of Figure 11. This mould is the holotype, figures 11 and 12 being a cast prepared from it. (F.30160.)

Conocardium gogoense, sp. nov.

Fig. 14.—Basal view of the holotype showing the widely gaping nature of the shell and the crenulated inferior margin. (C.57, University of W.A.)

Fig. 15.—Dorsal view of Figure 14, showing well developed lunule and straight hinge-line.

Fig. 16.—Side view of Figure 14, showing general outline of the shell and wide cordiform slope.

Conocardium sowerbyi De Koninck.

Fig. 17.—Side view of neotype showing characteristic ornamentation. (F.40891.)

Fig. 18.—View of Figure 17, showing anterior cordiform slope with concentric striae and partly weathered radial ribs.

PLATE XIV.

Conocardium australe (McCoy).

Fig. 1.—A side view of a large valve with most of the posterior portion missing. (F.40897.)

Conocardium robustum, sp. nov.

Fig. 2.—A dorsal view showing the exceptionally wide anterior cordiform slopes and position of the rostrum. (F.17750.)

Fig. 3.—Basal view of Figure 2, showing gape and flattened surface.

Fig. 4.—Side view of Figure 2, showing oblique anterior keel and the length of the shell in comparison to the height.

Fig. 5.—Basal view of the holotype showing the gaping nature of the shell and the crenulated inferior margins. (F.40916.)

Fig. 6.—Dorsal view of Figure 5, showing anterior cordiform slopes, lunule and widely separated umbones.

Fig. 7.—A side view of Figure 5, showing the general outline and the oblique median region.

Conocardium australe (McCoy).

Fig. 8.—A side view showing the anterior keel and ornamentation. (F.29924.)

Fig. 9.—The holotype (after McCoy) showing impressed furrows on the cordiform slope.

Conocardium robustum, sp. nov.

Fig. 10.—An internal cast showing fairly well preserved ornamentation. (F.21928.)

Conocardium truncatum, sp. nov.

Fig. 11.—A side view of the holotype. An internal cast showing the flattened cordiform slope and even convexity of the remainder of the valve. (F.37827.)

The dimensions of all figured specimens are given in the text.

Photographs by Mr. G. C. Clutton.

MINERALOGICAL NOTES. No. VI.*

By T. Hodge-Smith,
The Australian Museum.

(Figures 1–16.)

Contents.

Wolframite, New South Wales.
Apophyllite, New South Wales.
Cassiterite, Emmaville, New South Wales.
Phosphate Deposit, Cathcart, New South Wales.
Microlite, Euriowie, New South Wales.
Scheelite, Hatcher's Creek, Northern Territory.
Tantalite, Finniss River, Northern Territory.

Wolframite.

New South Wales.

(Figs. 1–10.)

Two contributions have been made to the classification of the minerals of the wolframite series in New South Wales. Mr. George Smith (1936, p. 132) makes the general statement that "it then appears that wolframite which contains a larger percentage of manganese than iron has only been identified as occurring in one part of the State [apparently Yalgogrin—T.H.-S.] and the tungsten mineral so plentifully distributed should be classified as ferberite". He points to the difficulty in deciding when a mineral should be classed as wolframite or as ferberite and states that "it is difficult to draw a line of division between what are really variations of the one mineral".

Mr. E. J. Kenny (1928, p. 178) states that: "The principal ores of tungsten worked in New South Wales are: Wolfram, tungstate of iron and manganese. . . . Other less important ores are: Ferberite, tungstate of iron; Hubnerite, tungstate of manganese. . . . The ore from Torrington may be classified as 'Ferberite'."

It is obvious from these two statements that there is no agreement as to the classification of the wolframite series in New South Wales.

E. S. Dana (1892, p. 983) states that in wolframite, Fe:Mn chiefly 4:1 and 2:3, but varying from 9:1 to 2:3.

F. L. Hess (Hess and Schaller, 1914, p. 37) defines ferberite as "a monoclinic iron tungstate having when pure the composition $FeWO_4$. It may contain not more than twenty per cent. of the hubnerite molecule $MnWO_4$", and hubnerite as $MnWO_4$ containing not more than twenty per cent. of the ferberite molecule. While wolframite contains the hubnerite molecule in all proportions between twenty per cent. of $FeWO_4$ and eighty per cent. of $MnWO_4$, and eighty per cent. of $FeWO_4$ and twenty per cent. of $MnWO_4$.

A. K. Boldyrew and E. J. Liasky (1929, p. 242) divide the series into hubnerite containing up to five per cent. of $FeWO_4$; ferrohubnerite from five to twenty-five per cent. of $FeWO_4$; manganowolframite from twenty-five to forty per cent. of $FeWO_4$; wolframite from forty to sixty per cent. of $FeWO_4$; ferrowolframite from sixty to seventy-five per cent. of $FeWO_4$; manganoferberite from seventy-five to ninety-five per cent. of $FeWO_4$; and ferberite more than ninety-five per cent. of $FeWO_4$.

* For No. V, see Records of the Australian Museum, xix, No. 3, 1934, p. 165.

Both C. Doelter (1928, p. 846) and W. E. Ford (1932, p. 771) adopt the classification suggested by Hess and Schaller (1914, p. 37).

E. T. Wherry (1914, p. 501) bases his classification on the C.I.P.W. classification for igneous rocks, thus:

Permanganowolframite	Mn:Fe 7:1.
Domanganowolframite	Mn:Fe between 7:1 and 5:3.
Ferromanganowolframite	Mn:Fe between 5:3 and 3:5.
Doferrowolframite	Mn:Fe between 3:5 and 1:7.
Perferrowolframite	Mn:Fe 1:7.

He urges that none of these names, including the names of the end-members, should be used as mineral names for arbitrarily partitioned off portions. This leaves the names hubnerite for pure $MnWO_4$, ferberite for pure $FeWO_4$, and wolframite for the remaining members of the series.

From the above brief review of the various classifications it will be seen that there is considerable difference of opinion as to the proper division of this series of tungsten minerals. This is what might be expected, as any division must be necessarily arbitrary. If the majority opinion is taken from the above outline, then the classification of Hess and Schaller would be adopted, but, as Wherry very clearly points out, such a classification is mineralogically quite unsound.

Taking plagioclase as perhaps the best known example of an isomorphous series of two molecules, it is found that the names of the end members, albite and anorthite, are used as names for the molecules $NaAl_2Si_3O_8$ and $CaAl_2Si_2O_8$ respectively. The intermediate series are divided artificially into a number of members which are easily distinguishable without recourse to chemical analysis. These divisions play a very important part in the classification of rocks and are therefore useful. This well established division of the intermediate series of the plagioclases is mineralogically unsound, but can be defended on the grounds of utility and ease of determination.

Applying these principles to the wolframite series, the insistence of Wherry on the use of the names hubnerite and ferberite for the end members only is confirmed. Any division should apply only to the intermediate members of the series. The only method of determining any one of them is by careful chemical analysis. Schaller has shown the difficulty of interpreting the analysis and the same difficulty exists in regard to the New South Wales analyses.

The only locality in New South Wales where the mineral has been found well crystallized is in the Torrington district. No crystals have been found with sufficiently bright and smooth faces to give signals that would be of any use in tracing fundamental differences in crystal structure due to variations in the ratio of the two molecules. Even if such perfect crystals were obtainable it is doubtful whether the desired results could be established as the analyses show a varying content of tantalum and niobium.

A. K. Boldyrew and E. J. Liasky (1929, p. 242) have shown that the streak of the minerals changes from pale brown to almost black progressively from the hubnerite to the ferberite end of the series. They claim that the composition of the mineral can be determined by the colour of the streak to within fifteen per cent. of the molecular composition. The mineral from Rockvale near Torrington, New South Wales, containing eighty-five per cent. of $FeWO_4$ cannot be distinguished by this method from that from Hogue's Creek, New South Wales, containing seventy-two per cent. of $FeWO_4$, and these two minerals would receive different names both under the Boldyrew and Liasky and the Hess and Schaller classifications. It is clear that this method is not accurate enough for purposes of classification.

Other ordinary physical tests are equally unsuitable.

It is obvious that, unlike the plagioclase series, the wolframite series cannot be divided into easily distinguishable members. Further, it cannot be claimed that any such division is of any great practical use.

A common method of indicating the composition of the feldspars is by the symbol Ab_nAn_m. Such a method can be easily applied to the wolframite series by using the symbol Fb_nHu_m. The classification would then be:

Ferberite: $FeWO_4$ (Fb).

Wolframite: $(Fe, Mn)WO_4$ (Fb_nHu_m).

Hubnerite: $MnWO_4$ (Hu).

The majority of chemical analyses of New South Wales wolframites published have been carried out to determine only the amount of tungstic oxide present. In order to obtain somewhat better data the late Mr. H. P. White, formerly Chief Chemist, Department of Mines, kindly carried out four analyses on specially picked material, and Mr. R. O. Chalmers, Assistant Mineralogist, completed three such analyses. The result of this work together with some previously published analyses is given in Table I.

TABLE I.

Chemical Analysis of New South Wales Wolframite.

Constituent.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WO_3 ..	75·26	75·54	70·73	76·17	73·67	75·48	74·90	76·50	76·21	77·64	74·56	62·79	73·96	76·30	76·60
Nb_2O_5* ..	0·26	0·57	Abs.	Abs.	1·95	0·52	Abs.	0·36	0·31	..	1·10	Abs.	..	..	
FeO ..	20·15	20·40	18·13	17·68	18·85	20·07	20·44	16·88	16·53	18·76	18·64	5·39	15·84	23·70	
MnO ..	3·94	3·07	3·64	5·09	5·21	3·26	3·28	6·36	6·62	4·12	4·46	14·46	3·05		23·40
SiO_2 ..	0·30	..	..		0·39	0·29	..	0·17	..		0·75	..	2·84		
CaO ..	0·29	0·12	1·64	Abs.		0·50	0·48	Abs.	0·09		0·47	Abs.	2·48		
MgO ..	0·16	..	..	Abs.		0·09	Trace	Abs.			0·20	Abs.	0·31		
H_2O ..			..	Abs.			0·26					0·13	0·30		
Gangue ..			5·55	1·34			0·52					17·09	..		
Al_2O_3 ..													0·88		
Bi_2O_3 ..													0·18		
SnO_2 ..				Abs.								Abs.	Abs.		
	100·36	99·70	99·69	100·28	100·07	100·21	99·88	100·27	99·76	100·52	100·18	99·86	99·84	100·00	100·00

*Including Ta_2O_5

1. Block 14, Torrington. Analyst H. P. White.
2. R. Smyth's Mine, Torrington. Analyst R. O. Chalmers.
3. Bismuth Mine, Torrington. Analyst H. P. White (Smith, 1926).
4. James Mine, Torrington. Analyst H. P. White (*Ann. Rpt. Mines*, 1920, 126).
5. Deepwater. Analyst H. P. White.
6. Rockvale Mine, Tungsten. Analyst H. P. White.
7. Rockvale Mine, Tungsten. Analyst H. P. White (*Ann. Rpt. Mines*, 1919, 186).
8. Hogue's Creek near Dundee. Analyst R. O. Chalmers.
9. Glen Eden near Glen Innes. Analyst R. O. Chalmers.
10. Inverell. Analyst A. Liversidge (Liversidge, 1882, 42).
11. Waukeroo, Yanco Glen, Barrier District. Analyst H. P. White.
12. Restdown Mine, Yalgogrin. Analyst H. P. White (*Ann. Rpt. Mines*, 1920, 126).
13. Pulletop. (*Ann. Rpt. Mines*, 1908, 183.)
14. Theoretical composition of ferberite.
15. Theoretical composition of hubnerite.

The presence of niobium and tantalum in all the later analyses carried out by White and Chalmers is of interest because in some of White's earlier analyses he records the absence of these elements. He considered that his later results are the more reliable, and that these elements are probably present in all New South Wales wolframite.

In 196 analyses given by Doelter (1929) only nine record the presence of niobium and/or tantalum. Of the 95 analyses quoted by Hess and Schaller (1914), fifteen record their presence. The greatest amount is that in the wolframite of Cave Creek, Arizona, which gives 2·20 per cent. of $(Ta, Nb)_2O_5$.

It seems probable that the presence of tantalum and niobium in wolframite is much more general than the published analyses would indicate.

The comparatively high lime content is remarkable when it is considered that the crushed material was examined under the microscope before analysis. It is considerably

less than some of the older analyses, and may be a reflection of the degree of care taken in picking the sample.

The tungsten molecules calculated according to the method of Hess and Schaller from the analyses are shown in Table II. The symbols (*a*) are obtained by recalculating the ferberite and hubnerite molecules to 100 per cent. and taking the nearest whole numbers. Symbols (*b*) have been calculated by a simpler method, giving results which are sufficiently accurate for purposes of classification. Instead of utilizing all the CaO and MnO to form $CaWO_4$ and $MnWO_4$, and then using the remaining WO_3 to form $FeWO_4$, the MnO and FeO are taken to form the hubnerite and ferberite molecules. The values are recalculated to 100 per cent. and the nearest whole numbers taken for the symbol. Taking analysis No. 1, in which the percentage weights of MnO and FeO are 3·94 and 20·15 respectively, then:

$$MnO \times \frac{WO_3}{MnO} = WO_3 + MnO = MnWO_4$$

$$3{\cdot}94 \times 3{\cdot}27 = 12{\cdot}88 + 3{\cdot}94 = 16{\cdot}82$$

Similarly for $FeWO_4$

$$20{\cdot}15 \times 3{\cdot}22 = 64{\cdot}88 + 20{\cdot}15 = 85{\cdot}03$$

101·85

Recalculated to 100 per cent.	
$MnWO_4$ ..	16·62
$FeWO_4$ ..	83·38
	100·00

Thus the symbol (*b*) for this wolframite is $Fb_{83}Hu_{17}$.

It is to be noted that, except in the case of the two analyses which include an appreciable amount of gangue, the agreement of the symbols calculated by the two methods is close and, further, is unaffected by the amount of $CaWO_4$ present. For purposes of classification the more simply calculated symbol (*b*) has been taken.

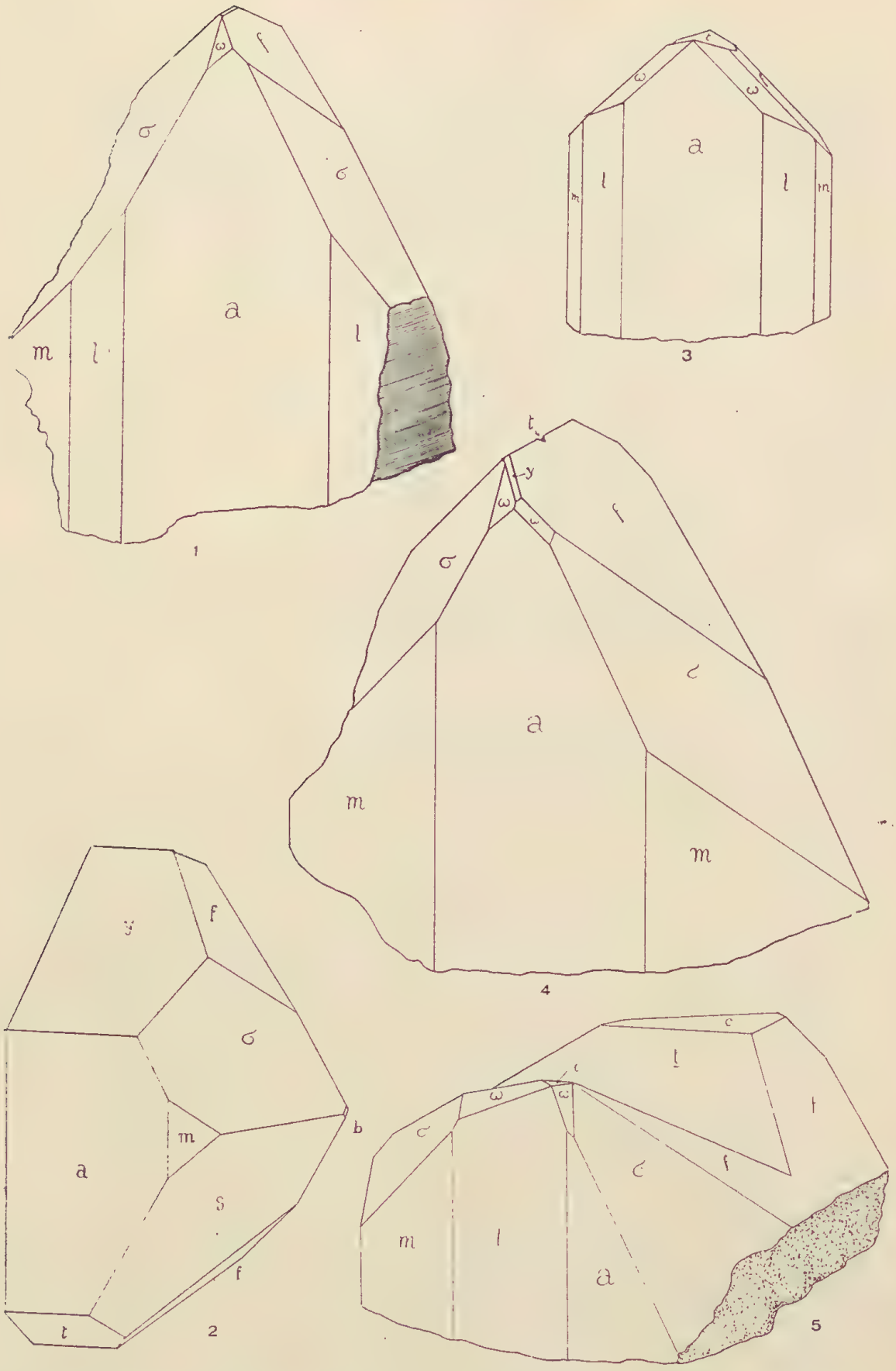
TABLE II.

Composition and Classification of New South Wales Wolframite.

Analysis.	$CaWO_4$.	$MnWO_4$.	$FeWO_4$.	Excess of FeO (f), or WO_3 (w).	Other Constituents.	Total.	Symbol (*a*).	Symbol (*b*).	Difference of Symbols in Units.
1	1·49	16·82	80·18	f 1·15	0·72	100·36	$Fb_{83}Hu_{17}$	$Fb_{83}Hu_{17}$	0
2	0·62	13·11	85·19	f 0·21	0·57	99·70	$Fb_{83}Hu_{17}$	$Fb_{83}Hu_{17}$	0
3	8·43	15·54	68·20	f 1·97	5·55	99·69	$Fb_{81}Hu_{19}$	$Fb_{83}Hu_{17}$	2
4	nil	21·72	74·61	w 2·61	1·34	100·28	$Fb_{77}Hu_{23}$	$Fb_{77}Hu_{23}$	0
5	nil	22·24	74·23	f 1·26	2·34	100·07	$Fb_{78}Hu_{22}$	$Fb_{77}Hu_{23}$	1
6	2·57	13·92	82·24	f 0·58	0·90	100·21	$Fb_{86}Hu_{14}$	$Fb_{86}Hu_{14}$	0
7	2·46	14·00	81·52	f 1·12	0·78	99·88	$Fb_{85}Hu_{15}$	$Fb_{86}Hu_{14}$	1
8	nil	27·16	71·23	w 1·35	0·53	100·27	$Fb_{72}Hu_{28}$	$Fb_{72}Hu_{28}$	0
9	0·46	28·27	69·76	w 0·96	0·31	99·76	$Fb_{71}Hu_{29}$	$Fb_{71}Hu_{29}$	0
10	nil	17·59	79·17	w 3·76	nil	100·52	$Fb_{82}Hu_{18}$	$Fb_{82}Hu_{18}$	0
11	2·42	19·04	76·05	f 0·62	2·05	100·18	$Fb_{80}Hu_{20}$	$Fb_{81}Hu_{19}$	1
12	nil	61·74	20·32	f 0·58	17·22	99·86	$Fb_{25}Hu_{75}$	$Fb_{27}Hu_{73}$	2
13	12·75	13·02	66·84	w 2·72	4·51	99·84	$Fb_{84}Hu_{16}$	$Fb_{84}Hu_{16}$	0

An examination of Table II shows that the composition of the New England wolframites varies from $Fb_{86}Hu_{14}$ at Tungsten to $Fb_{71}Hu_{29}$ at Glen Eden. The other New South Wales wolframites lie within these limits, except that from Yalgogrin which has a composition of $Fb_{27}Hu_{73}$, and all are definitely wolframite.

As previously stated, no crystals possess sufficiently bright faces for accurate measurement. Six crystals were measured on a two-circle goniometer and one, crystal ii, with a contact goniometer, and the readings can only be regarded as suitable for recognition of the forms present. The faces of the form $\omega(111)$ nearly always gave good signals and those of the form f(011) sometimes gave bright signals, but generally they were multiple, probably due to twinning.

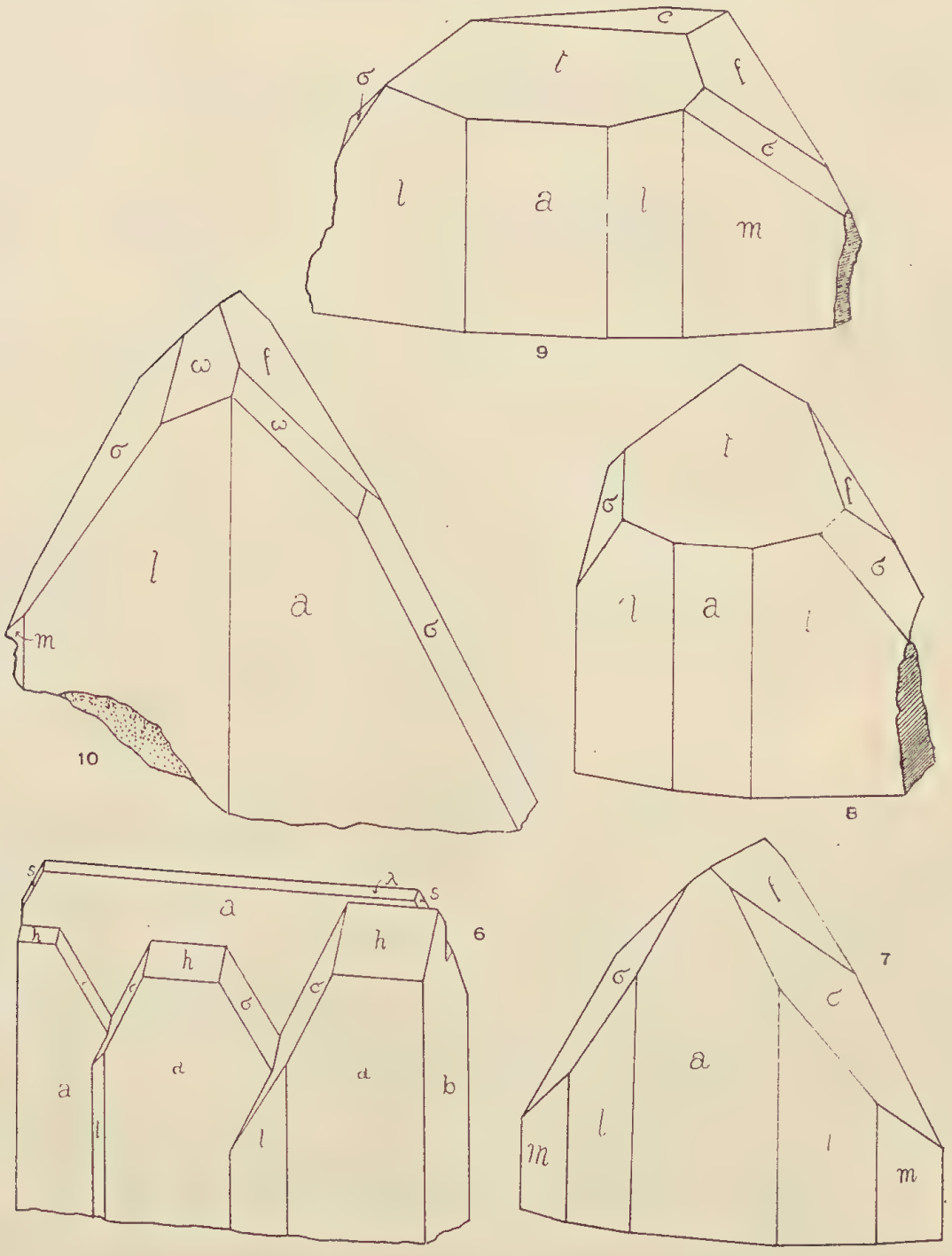


Figs. 1-5.—Wolframite from New South Wales. 1 and 5, R. Smyth's Mine, Tungsten. 2, Heffernan's Wolfram Mine, Torrington. 3, Torrington District. 4, Block 14 Mine, Bismuth. *Forms*: c(001), b(010), a(100), l(210), m(110), f(011), y(102), t($\bar{1}$02), ω(111), σ(121), s($\bar{1}$21).

Twinning is quite common with the *c* axis as the twin axis and the composition plane parallel to a(100). None of the crystals examined showed twinning on K(023) as recorded by Rose (1845) for wolframite crystals from Zinnwald.

Crystal i (Fig. 1) from R. Smyth's Mine, Tungsten, is typical of the habit of the untwinned crystals. It measures 18 mm. × 15 mm. × 10 mm. and is about average size for this type of crystal. Australian Museum number D 27930.

Crystal ii (Fig. 2) from Heffernan's Wolfram Mine, four miles north-north-west of Torrington, is unique among the crystals in the collection. It resembles somewhat a crystal of wolframite from the Sheperd and Murphy Mine in the Mount Bell district, Tasmania (Hodge-Smith, 1930, p. 413). It measures approximately 6 cm. × 4 cm. × 5 cm.



Figs. 6-10.—Wolframite from New South Wales. 6, Glen Eden. 7-10, Wild Kate Mine, Torrington, after C. Anderson (Anderson, 1904 and 1920). *Forms*: c(001), b(010), a(100), l(210), m(110), f(011), t($\bar{1}02$), λ($\bar{1}01$), ω(111), σ(121), s($\bar{1}21$).

It is not known whether it is part of a much larger crystal or whether it was attached by the large cleavage face present. Australian Museum number D 27939.

Crystal iii (Fig. 4) from Block 14 Mine, Bismuth, near Torrington, and crystal iv (Fig. 3) from the Torrington district, are typical of the twinned crystals. Australian Museum number D 22025. Crystal v (Fig. 5) from R. Smyth's Mine is also a fairly common type. Australian Museum number D 27929.

Crystal vi (Fig. 6) from Glen Eden consists of three individuals in parallel growth, all twinned in regard to the fourth individual. It is quite exceptional in habit. Australian Museum number D 22707.

Crystal vii is similar in habit to crystal iii and has not been drawn.

Crystals viii to xii (Figs. 7–10), after Anderson (1904 and 1920), are all from Wild Kate Mine, Torrington. In his descriptions he points out the impossibility of getting accurate readings.

TABLE III.

Combination of Forms in Crystals of Wolframite, New South Wales.

Forms.	Crystals.											
	1	2	3	4	5	6	7	8	9	10	11	12
c(001)	x				x						x	
b(010)	c	x			c	c						
a(100)	x	x	x	x	x	x	x	x	x	x	x	x
l(210)	x			x	x	x	x	x	x	x	x	x
m(110)	x	x	x	x	x		x	x	x		x	x
f(011)	x	x		x	x				x		x	x
h(101)						x						
y(102)								x				
t($\bar{1}$02)	x		x	x	x		x	x		x	x	
λ($\bar{1}$01)						x						
ω(111)	x		x	x	x							x
o($\bar{1}$11)					x		x			x	x	x
σ(121)	x	x	x		x	x		x	x	x	x	x
s($\bar{1}$21)		x				x		x		x	x	x

c indicates that b(010) is present only as a cleavage plane.

Apophyllite.

New South Wales.

(Figs. 11–14.)

Some crystals of apophyllite were discovered by Mr. M. Mawby at the 1,702-foot-level of the Zinc Corporation Mine, Broken Hill. This is the first record of this mineral at Broken Hill.

Mr. Mawby states that the crystals were found in a watercourse in quartzitic ore carrying sphalerite. He suggests that the apophyllite has been derived by the zeolitization of the sericitic schists.

Associated with the apophyllite is calcite. Sometimes the apophyllite is directly on the quartz and at other times the calcite is. There does not appear to be any regular arrangement of the minerals that would indicate any regular periodic deposition. Some of the crystals of apophyllite exhibit definite zoning.

There is another possible origin differing from that offered by Mr. Mawby. The action of carbonated water on calcium silicate (wollastonite) in producing apophyllite at Auerbach has been noted by Streng, who suggests the following reaction:

$$2CaSiO_3 + CO_2 + 2H_2O = CaCO_3 + (H_2CaSi_2O_6 + H_2O).$$

The presence of wollastonite has been recorded from the 530-foot-level of the South Blocks Mine (Hodge-Smith, 1923), and it is possible that carbonated waters passing downwards along water channels have reacted on lime silicates such as wollastonite and deposited apophyllite and calcite at this comparatively great depth.

The crystals (Australian Museum number D 34888) vary in size from 2 mm. to 20 mm. measured along the vertical axis. They are pyramidal in habit (Fig. 11), the pyramid being p(111). The small prism faces a(100) are invariably strongly striated parallel to the vertical axis. It does not appear that the basal plane is ever present. Those crystals in which the form appears have lost their apices by being knocked and cleaving along the perfect basal cleavage.

Prospect.

Although the dolerite intrusion at Prospect has been worked for many years by a number of quarries, and such minerals as analcite, prehnite, scapolite, stilbite, thomsonite, calcite and dolomite have been recorded, apophyllite has never been found until recently, when it was recognized by Mr. J. J. Johnston.

The mineral occurred in a large vesicle probably measuring a foot in diameter. The first mineral to form was prehnite, followed by pectolite and calcite, and finally apophyllite crystallized on the pectolite. Incidentally, although pectolite has been known for a number of years to occur at Prospect, its presence does not seem to have been recorded.

The colour of the apophyllite is an exceedingly pale pink forming a pleasing contrast with the pure white radiating fibrous pectolite which unfortunately does not retain its colour. In the course of a few months it becomes a dull brown on the surface.

While the crystals of apophyllite (Australian Museum number D 34921) appear to be bright, when examined on the goniometer they are found to be etched, giving poor signals making accurate measurement impossible. They are constant in habit (Fig. 13), consisting of short prisms a(100) terminated by the basal plane and the pyramid p(111). In one crystal fragment the somewhat rare form h(221) was recognized (Fig. 14).

General Occurrence in New South Wales.

Very little apophyllite has been found in New South Wales. The first record was made in 1924 (Hodge-Smith, 1924) from Ardglen, and only one specimen (Fig. 12: Australian Museum number D 21405) was obtained. The next record is by Dr. Germaine A. Joplin (1935) from the Hartley district. Here it is abundant in the calcareous bed on the northern limb of the Moyne Anticline, and was also found in a boulder in the Bonnie Blink Creek. No macroscopic crystals have been found; the record has been made from the examination of microscopic slides only. Dr. Joplin discusses the origin of the mineral.

Cassiterite Replacing Fossils.

Emmaville, New South Wales.

The occurrence of these interesting objects has been known to the miners of the district for a number of years under the names shell or snail tin and screw tin. The former name is applied to cassiterite replacing small gastropods, and the latter to that replacing fragments of crinoid stems. Generally only one segment of the crinoid stem is preserved, though pieces showing several segments have been found.

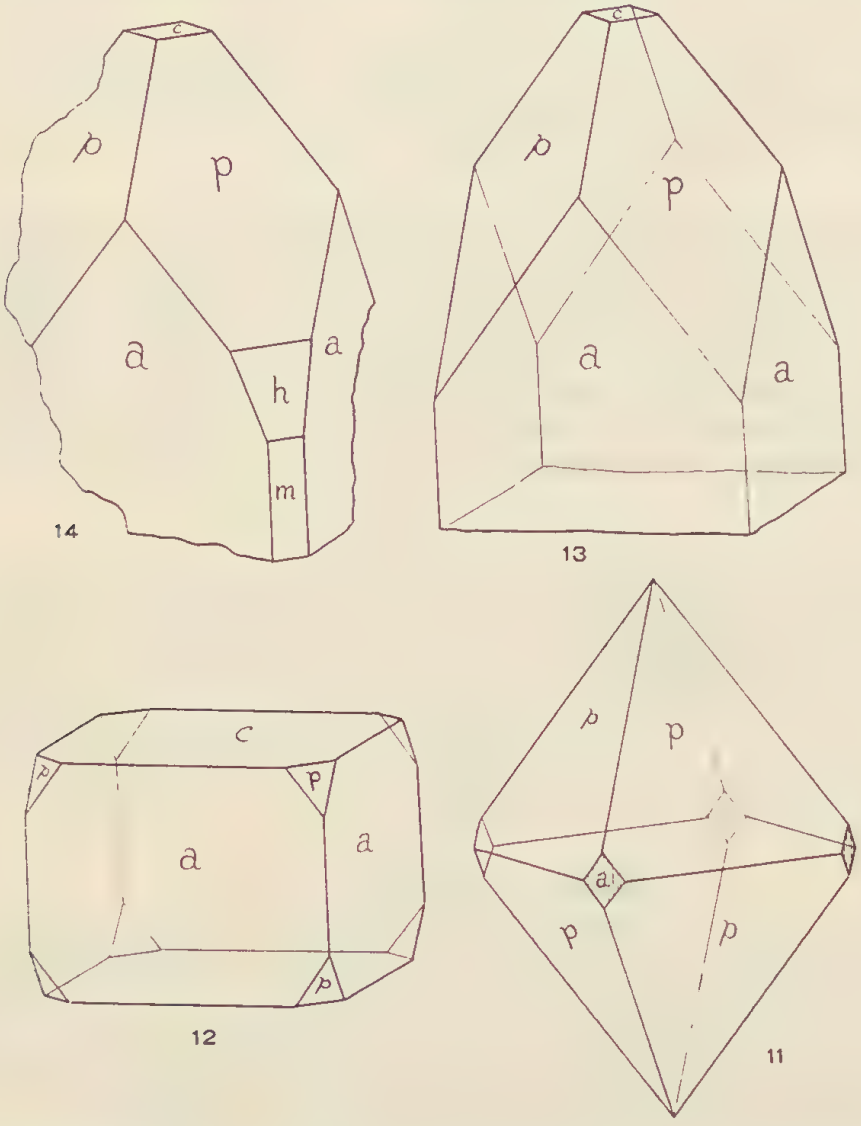
They are only known to occur in three small adjacent gullies about one mile north of the town of Emmaville, New South Wales. The two northerly gullies rise from the same shallow divide. That on the west is known locally as Steel's Gully, while the other apparently is unnamed. In these two gullies the screw tin is more abundant than the shell tin, while in the third gully, locally known as Charcoal Gully, the shell tin is the more common.

The gullies, mostly dry, have been worked long since for their alluvial cassiterite, and it is only after very heavy rain that it is regarded as at all worth while to recover cassiterite here.

In about a dozen "dishes" of dirt that I had washed from Steel's Gully, nine separate segments of crinoid stems were obtained from the concentrates which weighed about four pounds. The segments were very small, measuring only four millimetres in diameter. In two days' search I was unsuccessful in collecting any shell tin, though,

fortunately, I was able to secure a specimen. This measured 7 mm. by 6 mm. and has been identified as *Ptycomphalina* cf. *morrisiana* McCoy by Mr. H. O. Fletcher, Palaeontologist, Australian Museum.

The colour of both the shell tin and the screw tin varies from brownish-black to greyish-black. The cassiterite accompanying the fossils consists of a fairly even mixture of the ruby and black varieties with some resin tin. The size of the cassiterite grains varies considerably, but mostly they are about 2 mm. in diameter. One flat slug obtained in one of the dishes washed measured 25 mm. by 25 mm. by 6 mm., and was obviously part of a small vein from the country rock. A considerable number of small crystal fragments were obtained in the concentrates.



Figs. 11-14.—Apophyllite, New South Wales. 11, Broken Hill. 12, Ardglen. 13-14, Prospect. *Forms*: c(001), b(010), a(100), m(110), p(111), h(221).

The bed rock on which the alluvium rests is locally known as "trap". It consists of sedimentary rocks of Permian (Lower Marine) age. They consist of slates and conglomerates. Diligent search failed to find any fossils in these rocks. They strike East 20° North and dip northerly at an angle of 76°. There does not appear to be any true lode of cassiterite from which the detrital cassiterite has been derived. Granite, portion of the New England bathylith, underlies the sedimentaries at no great depth here. Tin-bearing solutions derived from this granite have invaded the overlying rocks forming a stockwork of innumerable veinlets of quartz, some of which are cassiterite-bearing. It was during this period of invasion that the fossil gastropods and crinoids were replaced by cassiterite. Some of the crinoid segments still have preserved

perfectly the minute hole left by the central canal of the stem, so that it is almost certain that these objects are pseudomorphs by substitution rather than by infiltration.

So far as I am able to find from the literature available, this constitutes the first record of cassiterite pseudomorphous after calcite and the first record of fossils composed of this mineral. It has been recorded as being pseudomorphous after quartz, orthoclase, and tourmaline from Cornwall; after feldspar from Tasmania; after hematite and magnetite from Mexico.

Phosphate Deposit.

Cathcart, New South Wales.

The deposit is situated in a small paddock on the eastern slope of Black Swamp, Portion 242, Parish Cathcart, County Wellesley, New South Wales. It came under the notice of the local residents by reason of the fact that crops would flourish in it when nothing would grow elsewhere. It was further noted that, on ploughing, white bone-like objects were turned over with the soil. Councillor H. Wiles, Shire President, became interested in the deposit, and Mr. R. Edwards secured some of the material and submitted it to the Museum for examination. Later Mr. Wiles took Mr. H. O. Fletcher, Palaeontologist, and myself to the deposit.

The soil is the typical basalt variety. About two chains towards the Black Swamp from the paddock a mica-hornblende-granite outcrops, while the hills above the deposit consist of olivine basalt of Tertiary age. In the south-western corner of the paddock a hole about eight feet deep had been made. The first three feet consisted of surface soil; underneath this is another three feet of thoroughly decomposed basalt which overlies a deposit of white phosphatic material in which fragments of fossil bone and wood were found. The contact of the decomposed basalt and the phosphatic material was quite irregular, and small veins of the latter passed irregularly up into the basalt. In part the altered rock is reticulated with thin veins of the white material.

Although actual contact of the phosphatic material and the underlying granite was not made, an examination of the occurrence clearly indicated that the granite was probably not more than two feet below the bottom of the hole.

The fossil wood is white and quite soft, having a hardness of not more than 2. In spite of its soft nature an excellent transverse section was obtained in a micro-slide.

Analysis of Fossil Wood, Cathcart.

			Approximate Mineral Composition.	
SiO_2	.. ..	7·38		
P_2O_5	.. ..	32·72		
Al_2O_3	.. ..	29·21		
CaO	.. ..	18·16	Tri-calcium phosphate	44
MgO	.. ..	4·21	Hydrous aluminium phosphate ..	32
H_2O	.. ..	7·62	Hydrous aluminium silicate ..	24
		99·30		100

The material is readily decomposed in acid with the separation of gelatinous silica. Iron, if present, can only be as a mere trace as there is not sufficient to impart the slightest colour to the ammonium precipitate. Fluorine is absent. The mineral composition given above can only be considered very approximate. The magnesia is considered as replacing lime in the tri-calcium phosphate.

The only other Australian record of phosphatized wood is by E. S. Simpson (1911) from Dandarragan, Western Australia. Here the replacing material is fluor-apatite (fluophosphate of lime) and dufrenite (hydrous phosphate of iron), and the fossil wood is preserved in Mesozoic sandstones. This occurrence is similar to that found in certain Cretaceous sandstones of the Russian districts of Smolensk, Orel, etc., except that dufrenite has not been recorded from here.

The bone fragments are also white in colour, but the hardness is considerably greater than that of the fossil wood. Only fragments of what appear to be rib and limb bones of a fairly large animal comparable with the extinct kangaroo were found. Under the microscope only traces of bone structure can be distinguished. External structures

have been lost largely, in many cases entirely. Quite a few of the fragments could not be recognized as bone.

Analysis of Fossil Bone, Cathcart.

SiO_2	2·38
CO_2	5·68
P_2O_5	36·66
Al_2O_3	0·76
CaO	46·66
MgO	3·86
MnO	trace
Na_2O	1·32
H_2O	3·59
F	absent
	100·91

Approximate Mineral Composition.	
Tri-calcium phosphate	80
Hydrous silicate	9
Magnesium carbonate	8
Calcium carbonate	3
	100

Again the material is decomposed by acid with the formation of gelatinous silica. It effervesces slightly in cold acid and, after this ceases, effervescence is renewed on warming. In determining the approximate mineral composition, all the magnesia is used to form carbonate, and sufficient lime taken to satisfy the remaining carbon dioxide and all the phosphorus pentoxide. The remaining constituents formed a hydrous silicate somewhat resembling zeolitic material.

Although the material chosen for analysis was considered to show traces of bone structure, the result of the analysis does not support the view that it is fossil bone. According to F. W. Clarke (1916, p. 524), A. Carnot has shown that fossil bone shows an enrichment of calcium carbonate, iron oxide, and especially fluorine. In the above analysis it is to be noted that fluorine is absent, iron oxide is present as a mere trace and is included with alumina, while the carbonate is mainly magnesium carbonate. Further, concretions are characterized by an absence of fluorine.

In discussing the origin of this deposit it will be seen that these bones have been subjected to conditions not found in ordinary bone deposits. The phosphatized wood, bone, and cementing material in the Cretaceous sandstones of Russia have all practically the same composition. In this case all three are different. An analysis was not made of the cementing material, but it differs from both the fossil wood and bone in that it contains 15·26 per cent. of insoluble material. This indicates a considerable difference in the mode of formation of the two deposits.

The Origin of the Phosphate Deposit.

The origin of the phosphatic material may be sought either in the basalt or in the granite since it lies between them or in organic remains which have been covered by the basalt. The basalt is notably deficient in phosphorus. The granite is quite a normal type and may contain less than one-half per cent. of normative apatite. If either were responsible for the deposit it would be reasonable to expect phosphates to occur right along the contact and not in a restricted area.

It is therefore necessary to assume that the phosphates were derived from organic remains. The occurrence suggests a small marsh or water hole to which animals came for water and in which the bones of these animals accumulated until the area became covered by the Tertiary lava flows. The bones would be immediately attacked by the waters accompanying the lava. The smaller bones would suffer complete decomposition, and only fragments of the larger bones would remain. The resulting phosphate solutions, acting on the lava, would form aluminium phosphate and possibly magnesium phosphate. These solutions, coming into contact with the wood of the marsh, were responsible for the replacement of the woody material by phosphates of lime, magnesia, and alumina. Under these conditions it is probable that the leached fluorine was carried away in solution. It is surprising to find practically no iron oxide present, and possibly it has been leached out subsequently by ordinary ground waters.

Microlite.

Euriowie, New South Wales.

A single crystal fragment of microlite was obtained by Mr. M. Mawby from Euriowie, New South Wales. It measured approximately 13 mm. × 10 mm. × 10 mm. Four faces of the octahedron are shown, but they are quite rough. The colour is brownish-yellow and the specific gravity 5·43. This is the first record of microlite for the State.

Scheelite.

Hatcher's Creek, Northern Territory.

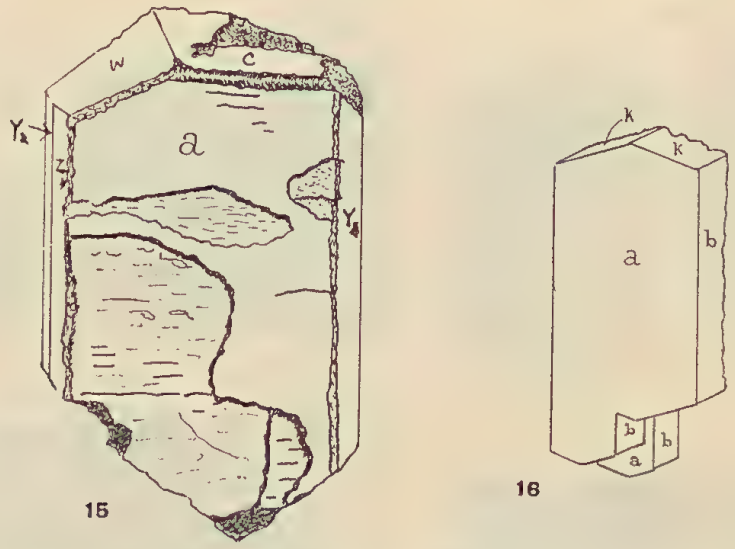
Mr. J. J. Johnston secured a crystal fragment of scheelite from Hatcher's Creek, Northern Territory. It measures 30 mm. along the intersection of two faces of the form e(011), which is the only form represented.

Tantalite.

Finniss River, Northern Territory.

(Figs. 15–16.)

Mr. A. E. Williams presented to the Museum some crystals of tantalite from Porter's Claim, Finniss River, Northern Territory (Australian Museum number D 35552). Two of these are considered worthy of description. No. 1 crystal (Fig. 15) measures 56 mm. along the vertical axis and 22 mm. and 30 mm. along the horizontal axes. The habit is stout prismatic, somewhat flattened parallel to the macropinacoid, the faces of which are very rough. The edges between the macropinacoid and the basal pinacoid are very rounded, suggesting the development of a macrodome. In some of the other crystals the macropinacoid is strongly striated horizontally and one shows a steep macrodome lying between i(101) and a(100), which may possibly be e(201).



Figs. 15-16.—Tantalite, Finniss River, Northern Territory. *Forms:* c(001), b(010), a(100), y(160), z(150), k(011), w(164).

Measurements were made by means of a contact goniometer and are therefore only approximate, but are sufficiently accurate and concordant for purposes of determination; in no case does the measured angle vary from the calculated angle by more than half a degree.

I can find no record of the large terminal face W(164). It lies in the zone [610] and the measured angle between it and the basal pinacoid is 30° 30′, while the calculated angle is 30° 9′.

Crystal 2 (Fig. 16) is doubly terminated, though one termination is much stepped. One of the macropinacoids is missing and it would appear that it was the plane of attachment of the crystal. The crystal measured 9 mm. by 15 mm. by 33 mm. along the a, b, and c axes respectively. The macropinacoid, unlike those of crystal 1, is quite bright.

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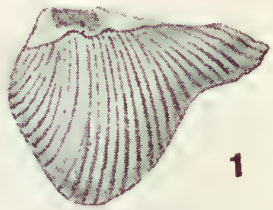
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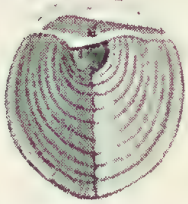
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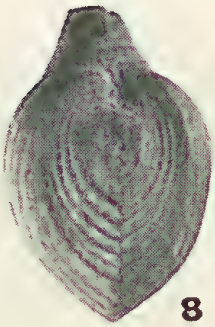
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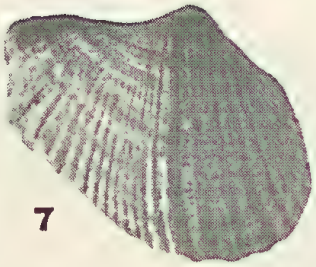
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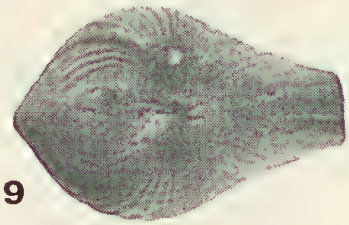
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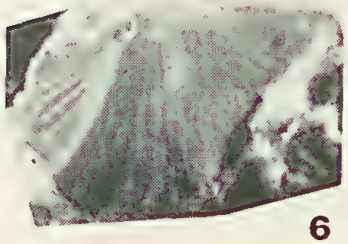
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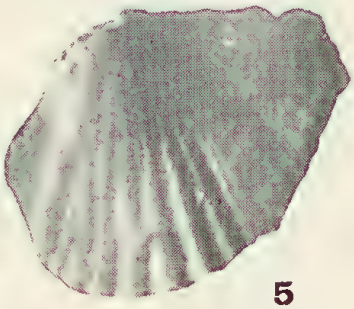
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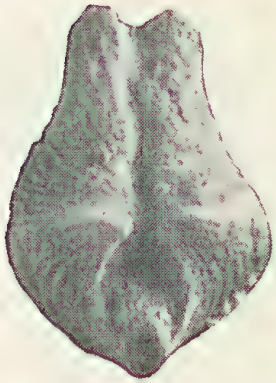
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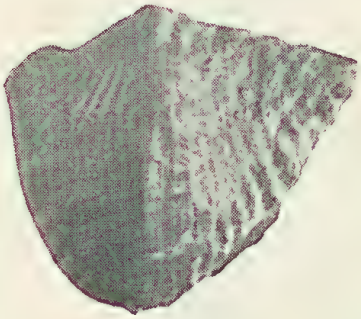
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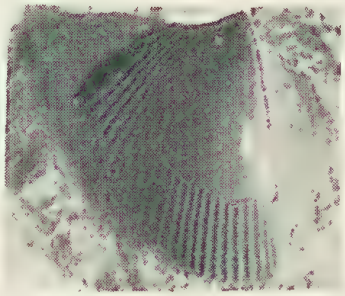
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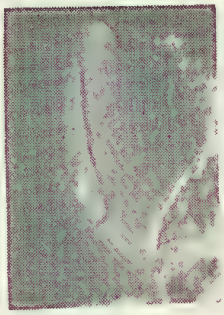
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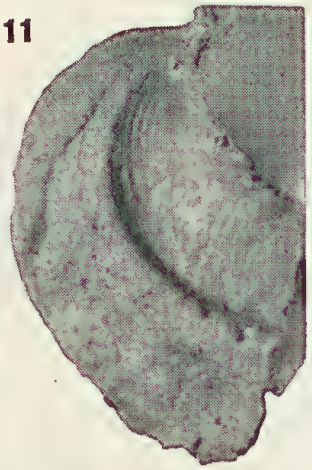
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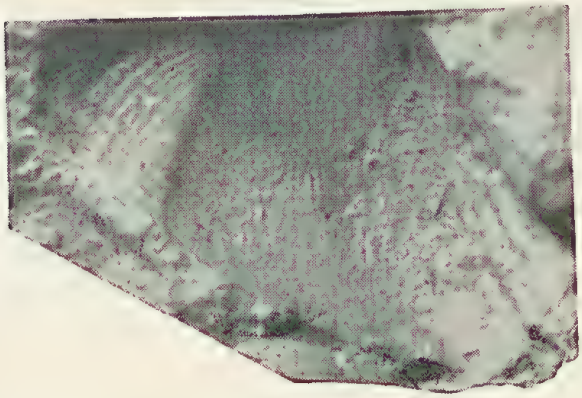
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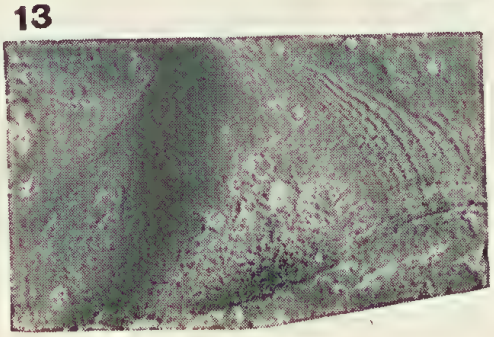
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Photo.—G. C. Clutton.

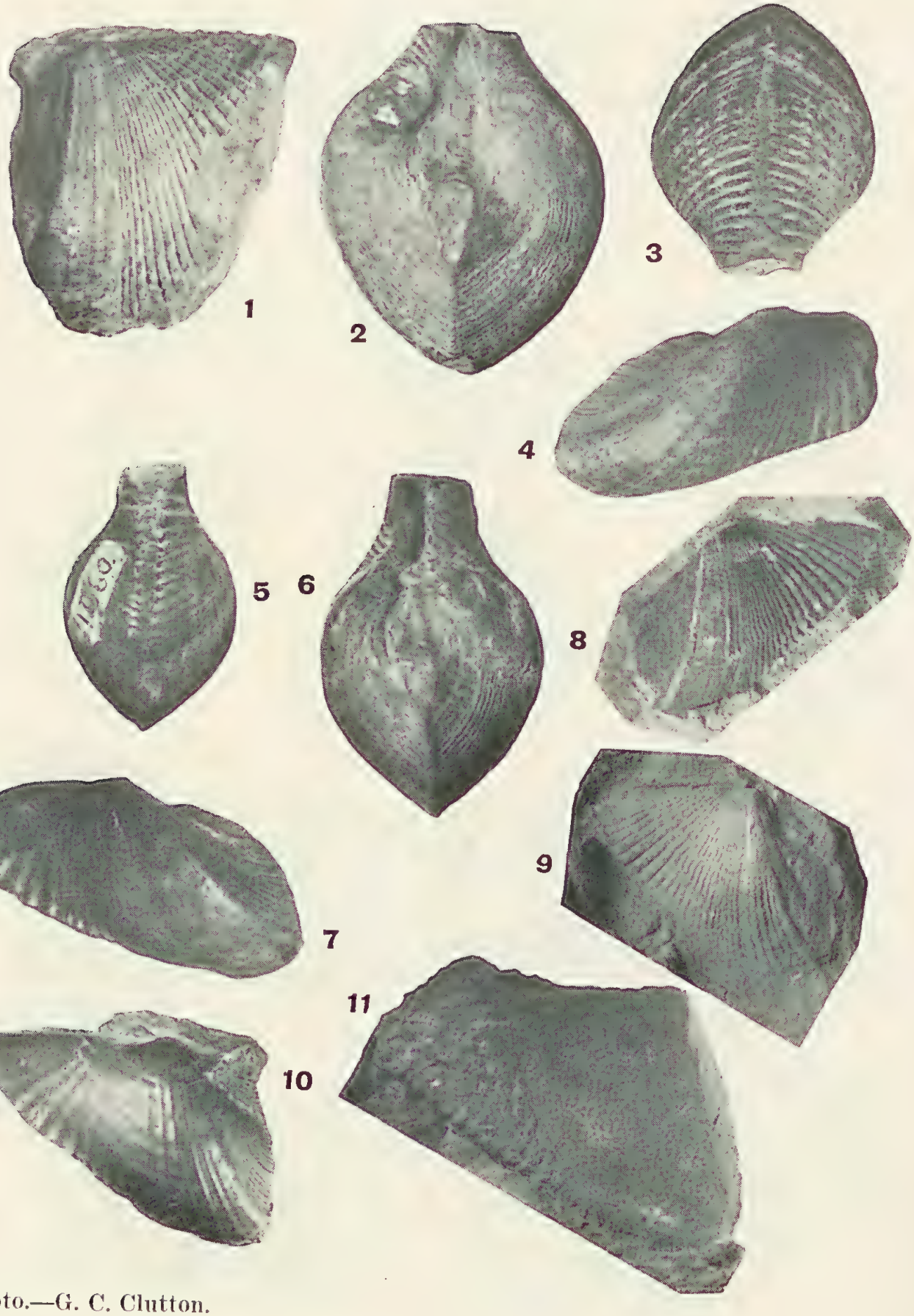

Photo.—G. C. Clutton.

SOME UNUSUAL CYLINDRO-CONICAL STONES FROM NEW SOUTH WALES AND JAVA.

By Frederick D. McCarthy.
The Australian Museum, Sydney.

(Plate xv.)

The specimens described in this paper are in the collection of the Australian Museum.

1. E.50489. Found on a claypan twelve miles from Bancannia Lake, and eighty-five miles north of Broken Hill, New South Wales (Plate xv, figs. 5*a*–*b*).—A straight conical stone, flattened oval in section. It is completely polished, except for a band 1 cm. wide round the base and the concave butt which form a hammer-dressed area. No flakes have been struck off the base round the butt. The distal end is a sharp-edged blade 2·75 cm. long formed by two ground facets 0·5 cm. wide; a large spall 6 cm. long is missing from one side of this end. The material is a gneissic rock. It bears simple but unusual incised markings. On one flattened surface (Fig. 5*b*) is a "laced" design extending from the blade to within 5 cm. of the butt; the longitudinal groove is deep and distinct, but the numerous transverse scratches are shallow and faint, irregularly spaced, and mostly at right angles to the groove. There is a curved longitudinal incised line on each side forming a frame round the transverse lines. There is a pit, 0·5 cm. in diameter, at the end of the central groove, and from it three more deeply incised grooves branch out on each side. On the other flattened surface (Plate xv, fig. 5*a*) is a stellate design 8 cm. in diameter; it consists of a central pit from which radiate approximately 34 lines, some of which are single scratches, but others are two joined together. Below it are several transverse incisions, one pair being broad and deep, and above it is a number of single straight incisions. Presented by Mr. A. R. Campbell.

The designs on both surfaces of this stone are unique. The "laced" design without a frame occurs commonly on cylindro-conical stones, but the stellate design is the only one of its type known to the author. The latter design is represented among the rock engravings at Yunta, South Australia (Mountford, 1935, plate x, fig. 6, p. 213), and at Mootwingee, far western New South Wales (Dow, 1938, 110, pl. i, fig. 5), and is frequently seen among the rock paintings of the Hawkesbury sandstone area extending inland from the central coast of New South Wales, where it is considered to be a representation of the sun.

2. E.50621. Lower Macquarie River, New South Wales (Plate xv, fig. 3).—The proximal end of a straight cylindro-conical stone. It is polished on half of its surface, and the remaining area is rough and weathered. According to an analysis made by Mr. T. Hodge-Smith, Mineralogist, Australian Museum, it is made of white kaolin. It is 9·5 cm. long and 7 cm. in diameter, and was presented by Mr. P. J. Brennan. Etheridge (1916) recorded numbers 2, 8, 21, 29, and E made of clay, number 6 made of pipeclay, and number 30 of *kopi*, but in the series of four hundred and fifty specimens described by Black (*Cylcons*, 1943) none were made of these materials.

3. E.50752. Bulga, Hunter valley, New South Wales (Plate xv, fig. 2).—The proximal end of a straight cylindro-conical of flattened-oval section. The surface is polished, and covered with numerous parallel cuts or gashes up to 1 cm. long. The material is argillaceous sandstone. It is 8 cm. long, 7 cm. wide, and 5 cm. thick, and was presented by Mr. A. N. Eather. This specimen was listed by Black (1943, 18, 100) from Thurrabri, but it was collected by the donor on an old camp-site at Bulga, the furthest point east at which cylindro-conicals have been found. It may have reached this locality from further west as an object of magical significance by means of ritual exchanges at tribal meetings for ceremonies.

4. E.50640. South-west Queensland (Plate xv, fig. 1).—A conical-shaped piece of red ochre. The distal end has been rubbed to a conical shape, and parts of the natural surface are showing elsewhere, including the butt. Flakes have been struck off round the base, and also on the distal end. It is oval in section. It is 20 cm. long, 6 cm. in diameter, and was presented by Mr. P. D. Riddell, who found it on a clay-pan. It is doubtful whether this specimen should be classified as a cylindro-conical, although it bears some of the characteristics of the group; it might be a piece of red ochre that was in use by a local native as a pigment for paint.

5. E.37554. Wilcannia (twenty miles east of), New South Wales (Plate xv, fig. 6).—A straight polished cylindro-conical made from a dark green basaltic stone; the surface has weathered to a light brown crust. The butt is concave, and round it flakes have been knapped in two series, one of which is old and weathered, the other recent with fresh flake-scars. The latter series of three might have been done by the finder seeking to ascertain the nature of the material. It is flattened-oval in section. There is a mortar or grinding depression on one surface, and it is 10 cm. long and 6 cm. wide, but very shallow. The distal end is a blunt blade 6 cm. long, with its edge in the middle line. It is 21 cm. long, 8 cm. wide, and 5·5 cm. thick, and was presented by the Sydney Technical College.

This cylindro-conical combines two unusual characters, namely, the worked depression and the broad bladed distal end.

6. E.7516–17. Darling River district (Plate xv, fig. 8).—Two straight cylindro-conicals made of sandstone, each bearing a well-used mortar depression. Etheridge (1916, 3) concluded that such use of cylindro-conicals was of a secondary nature, an opinion which is obviously correct. Very few cylindro-conicals have been used in this manner. One is 27 cm. long, 6·5 cm. thick, and has a mortar depression 15 × 6·5 cm., and 0·5 cm. deep. The other one is 18 cm. long and 6 cm. in diameter, with a mortar depression 13 × 5 cm., and 0·5 cm. deep. Presented by J. Milne Curran.

7. E.50490. Found on a claypan twelve miles from Bancannia Lake and eighty-five miles north of Broken Hill, New South Wales (Plate xv, fig. 9).—A straight cylindro-conical, oval in section, and made of slate. It is completely polished. The distal end is a blade 2·5 cm. long, formed by two ground facets each 0·75 cm. wide. There are percussion marks on each margin just below the corner of the blade. The butt is cupped, and flakes have been knapped round the base. This stone bears numerous incised markings. Most of its surface is covered with pairs, and a few sets of three and four, of transverse incisions of varying length; in a number of the pairs one of the incisions is in the form of a kangaroo-track, and there are many scattered single examples of the latter, but no pairs. Several longitudinal lines extend from end to end, and one of them joins together a series of five emu-tracks. There is a series of short incisions in vertical lines down one side, and another series of them fringing one facet of the bladed distal end. There is one isolated emu-track, and three small herring-bone designs. The most interesting feature of this cylindro-conical, not hitherto recorded, is that the butt is covered with numerous fine scratches, very close together, and all running the same way but at varying angles so that some cross others. It is 31 cm. long, 6 cm. wide, 4·5 cm. thick, and weighs 3 lb. It was found and presented by Mr. A. R. Campbell.

8. E.44779. G. Keroek, Nelipar, Java (Plate xv, fig. 7).—This exceptionally interesting artefact of cylindro-conical type was given to the author by Mr. Mounser, who had obtained a number of similar specimens from the above locality in the Djokjakarta district of Central Java. It is cylindrical and straight, and has a rounded conical distal end; the flat butt is at an oblique angle. It bears no incised markings nor have any flakes been knapped round its butt. It has been hammer-dressed and polished. The butt is very smooth, and bears in the middle a small pit 0·5 cm. wide and deep. The material is a fine-grained, compact grey rock.

Black (1943, 20) stated in error that this stone was obtained during archaeological excavations in Java. Mr. Mounser did not inform me whether he found these stones in an old or recent temple site, or whether he purchased them from the natives.

Incised markings on cylindro-conicals.—A comparison of specimens in the Australian Museum with those described by Etheridge and by Black reveals that several types of incised markings have not been recorded by either author. Etheridge (1916, 36) listed transverse and longitudinal lines, bird-tracks, simple pittings, herring-bone, cross, preputial or apical ring, median encircling or circumferential ring, and a spiral. Black (1943, 15) added the stellate design, but figured other types which he did not include in his list. Additions to the above series comprise the barred circle (Black, pl. xli, no. 22), crescent or boomerang-shape (Black, pl. xli, no. 22), kangaroo-tracks (on two Australian Museum specimens), oval formed by two crescentic lines overlapping at each end, and an M-shaped figure (on an Australian Museum specimen).

One of the most interesting features of the method of marking these stones is that the above series of simple designs were used in innumerable combinations, among which the so-called "laced" figure on the phacoid stones especially is the only one that is reproduced as a definite design on a number of cylindro-conicals. This lack of standardization of designs, and the variation in the arrangement of simple elements, are characteristic of Australian aboriginal art, and in some areas are of totemic significance. The markings on the cylindro-conicals appear throughout the pictographic and decorative art of Australia, and they represent a period extending from prehistoric to recent times.

9. *Bogan-type.* E.50909. Grong Grong, New South Wales (Plate xv, fig. 4).—A hammer-dressed elliptical artefact made of coarse granite. It is neatly rounded on its upper surface, and is flattened but undulating on its lower surface. One end is blunt but appears to have been in course of being pointed. The other end is conical, with a curved edge 2 cm. wide forming its point; it is not ground, but the surface is polished by use up to 4 cm. from the point all round the end. The surface is slightly weathered, and is a bright buff in colour. It is 23 cm. long, 9 cm. in diameter, and weighs 5 lb. Found and presented by Mr. H. Wright in 1943.

Another example, of which the Australian Museum possesses a cast, was found in 1935 near the upper Bogan River. It is very similar to the Grong Grong specimen, but is not as well shaped, and many humps and hollows have not been removed by the hammer-dressing. At each end is a conical point, one formed by three facets, the other by four facets, and the surface round both ends is polished by use in a similar manner to the Grong Grong specimen. It is 22 cm. long, 9 cm. in diameter, and about the same weight as the other example.

The function of these two artefacts is not known, but there is some reason to believe that they are crude examples of the grooved conical stones described by McCarthy (1939); they occur within the distribution of the latter group, the use-polished point and hammer-dressed surfaces are characteristic features of both groups. In view of the difficulty of referring to it in simple terms in literature, the name *Bogan*-type is proposed for the variety herein described.

10. A cylcon from Hughenden, Queensland, figured by Etheridge (1916, pl. ix, fig. 3).—It is hammer-dressed and at one end has a bevelled flange which forms the base, whilst the other end is pointed. Both Etheridge (1916, 35) and Towle (Black, 1943, 4) consider that its "workmanship appears to be too finished for that of an aboriginal hand", and the latter author suggests that it was fashioned by an extra-Australian people. It resembles several artefacts from the New Hebrides, the stone missile sticks (Etheridge, 1917, 194–97, pl. xxxvi, fig. 2, and pl. xxxviii, fig. 2), and the slaying-stone (Etheridge, 1917, 197, pl. xxxviii, fig. 4) of cylindro-conical form; both types are hammer-dressed. Thus the possibility should be considered that it was brought into Queensland by New Hebridean natives employed in this State during the late nineteenth century. On the other hand, its workmanship is equalled in Australia by the grooved conical stones, tanged artefacts, and some of the hammer-dressed axes and adzes. Its flanged base is unique among Australian cylcons, and in this connection might be mentioned the New Caledonian ceremonial greenstone axes, the bases of which are of the same shape.

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EXPLANATION OF PLATE XV.

Fig. 1.—Conical-shaped piece of red ochre, south-west Queensland. Austr. Mus. Coll. Regd. No. E.50640.

Fig. 2.—Portion of cylindro-conical stone, Bulga, N. S. Wales. Austr. Mus. Coll. Regd. No. E.50752.

Fig. 3.—Portion of cylindro-conical stone, Lower Macquarie River, N. S. Wales. Austr. Mus. Coll. Regd. No. E.50621.

Fig. 4.—*Bogan*-type from Grong Grong, N. S. Wales. Austr. Mus. Coll. Regd. No. E.50909.

Fig. 5*a-b*.—Cylindro-conical stone from claypan twelve miles north of Bancannia Lake, N. S. Wales. Austr. Mus. Coll. Regd. No. E.50489.

Fig. 6.—Cylindro-conical stone with mortar depression and bladed end, Wilcannia, N. S. Wales. Austr. Mus. Coll. Regd. No. E.37554.

Fig. 7.—Cylindro-conical stone from G. Keroek, Djokjakarta district, Java. Austr. Mus. Coll. Regd. No. E.44779.

Fig. 8.—Cylindro-conical stone with mortar depression, Darling River, N. S. Wales. Austr. Mus. Coll. Regd. No. E.7517.

Fig. 9.—Cylindro-conical stone from claypan twelve miles north of Bancannia Lake, N. S. Wales. Austr. Mus. Coll. Regd. No. E.50490.

Photos.—G. C. Clutton.

THE *WINDANG*, OR EDGE-GROUND UNIFACE PEBBLE AXE IN EASTERN AUSTRALIA.

By Frederick D. McCarthy.
The Australian Museum, Sydney.

(Plate xvi, figures 1–6.)

The Australian Museum possesses a series of one-hundred and eight axes of a type that may be considered transitional between the trimmed uniface pebble implements and edge-ground axes. The characteristics of the type are simple: it is made from a pebble, half of a split-pebble, or a slice from a pebble, trimmed partly or wholly on one surface only, with a blade ground on one or both facets.

Attention has been drawn to occasional specimens but the series has not been described, nor has attention been drawn to its affinities. In the following analytical description, the series is divided into two groups, coroid and split-pebble.

Coroid.

The varieties in this group are the same as the trimmed uniface pebble implements, and they have been classified according to the trimming to draw attention to the relationship. The ground-edge blade is always at one end.

(*A*). *Trimmed at one end* (Plate xvi, fig. 1).—The chipping is limited to one facet only. The butt end is lacking on two, and one has a trimmed concave edge adjoining the butt. The eighteen specimens range from 9 to 18 cm. long, 6 to 11 cm. wide, 2 to 5 cm. thick, and from 8 oz. to 3 lb. in weight. They range from round to elongate-oval in shape, and one from Prairie, Queensland, is pear-shaped.

Localities.—North Coast: Clarence River, Bulga (Hunter River Valley). *South Coast*: Quibray, Shellharbour (2), Bellambi. *Inland*: Gunnedah, Oberon (2), Bathurst (2), Nattai River, Waste Point (Snowy River) (3). *Queensland*: Prairie. *Victoria*: Cape Liptrap, Tarwin.

(*B*). *Trimmed on one lateral margin.*—There are few examples in the collection, and the trimming on them appears to have been done for shaping and not for use. The trimmed uniface pebble implements with lateral working edge are the most unsuitable type in the group for addition of the ground blade. There is, however, one example, E.49513 (Plate xvi, fig. 2), and it is a most unusual axe, from the Macquarie River, between Dubbo and Narromine. The trimmed lateral margin is steep-faced and step-chipped. The blade is ground on both surfaces at one end, but it has two facets separated by a ridge on the trimmed surface, and one on the crust surface. These three facets form a two-edged gouge-like blade. It is 14 × 7 × 4 cm., and 1 lb. 2 oz. in weight. It is made of a fine-grained indurated shale, and is elongate-oval in shape.

(*C*). *Trimmed on one or both lateral margins and end* (Plate xvi, fig. 3).—The trimming is limited to one margin and end on two specimens only, and is present on both margins and end on eighteen. On the latter series a tongue of crust extends from the butt along the surface between the trimmed margins. Two exceptions have the ground blade on the untrimmed end. They are all oval in shape, and range from 9 to 21 cm. long, 6·5 to 11 cm. wide, 2 to 6 cm. thick, and from 8 oz. to 3 lb. 8 oz. in weight.

Localities.—North Coast: Bulga (Hunter River Valley). *South Coast*: Quibray (2), Bellambi, Lake Illawarra (4), Shellharbour (4), Murramurang. *Inland*: Lower Macquarie River (Geurie parish), Glen Allan, Ginkin, Duckmaloi River (2), Bungonia. *Victoria*: Cape Otway.

(*D*). *Trimmed all over one surface* (Plate xvi, fig. 4).—Some are thick at the butt end and taper to the blade, others have a rounded crown in the middle of the flaked surface. The majority are oval in shape, but four are made from straight-sided pebbles, and two are pear-shaped. One from Cape Otway is elongate, straight-sided, and shoe-

shaped. Most of the thirty-eight specimens display the characteristic technique of the *sumatra*-type. Some of the others have a trimmed working edge along one lateral margin, and one along two margins. They range from 9 to 19 cm. long, 6 to 12·5 cm. wide, 2·5 to 6 cm. thick, and from 6 oz. to 3 lb. 4 oz. in weight.

Localities.—North Coast: Clarence River (North Arm), Woodburn, Woodville, Coff's Harbour, Myall Lakes, Raymond Terrace (2), West Maitland, Bulga (2), Paterson River. *South Coast*: Bellambi (2), Burrawang (2), Sassafras (Shoalhaven River) (2), Murramarang (3), Merimbula, Bermagui, Lake Illawarra (2), Wollongong, Shellharbour. *Inland*: Nymboida, Walcha, Inverell, Boorook, Ando, Jindabyne, Hampton (Blue Mountains), Argyle, junction of Murrumbidgee and Cotter Rivers. *Victoria*: Cape Liptrap, Cape Otway. *Queensland*: Springsure.

Split-Pebble. (Plate xvi, fig. 5.)

Thirty-seven are made from one of the two portions of a split-pebble or from a pebble slice. The cleavage surface distinguishes them from the coroid group; it is trimmed along one or both lateral margins on eighteen, and is continued round the butt on an additional nine. Some are untrimmed and have a smooth, slightly convex, cleavage surface. In the splitting of the pebbles the knappers selected the most suitable spot on the margin at which a blow would produce the desired result; thus the impact spot is on one corner or in the middle of the butt on seventeen, in various positions along one lateral margin on seventeen, and indeterminate on three. They are all oval in shape, and range from 9 to 16 cm. long, 7 to 12 cm. wide, 1·5 to 4 cm. thick, and from 4 oz. to 2 lb. 8 oz. in weight.

Localities.—North Coast: Richmond River, Crescent Head Beach (2) and quarry (1), Arakoon, Woodville, Anna Bay. *South Coast*: North Cronulla (2), Bellambi (2), Lake Illawarra (4), Bermagui (2), Shellharbour (4), Tilba Lake (2). *Inland*: Stradbroke (Paterson River) (2), Duckmaloi River (2), Glenbrook and Blaxland (Blue Mountains), Richmond, Emu Plains, Rockton, Jindabyne, Eugowra, Murrumbidgee and Naas Junction, Louth. *Victoria*: Dellicknora.

Analysis.

Trimming.—The trimming on these axes is the same as that on the uniface pebble implements lacking the ground-blade. Exceptions to be noted are: (1) the end trimmed variety in the coroid group, on which the trimming often appears to be for the purpose of simplifying the grinding of the blade, and (2) the trimmed uniface lateral margin type which is unsuitable for use as an axe in most instances and is represented by only one specimen in this series.

A minority have odd flakes struck off the crust surface, some due to battering or percussion use, but none of these are trimmed intentionally along the margins of this surface.

Blade.—The application of the grinding technique to trimmed uniface pebble implements is of some interest because it indicates that they were in use at the time of the diffusion of this technique in eastern Australia. Some of them may be tools discarded by previous generations, and subsequently picked up and made into axes after the introduction of the ground blade. On the great majority, eighty-two, the blade is ground on both facets, but twenty-six are ground on the trimmed facet only, and on ten of the latter there is use-polish on the crust surface at the same end. Two of the split-pebble examples, E.4604, North Cronulla, and E.46011, Dellicknora, Victoria, have narrow blades ground on both facets at each end. On most of the specimens the ground facets, which are from 0·5 to 4 cm. wide, are broader on the trimmed surface than on the crust side, and on the former surface the facet may be gapped and irregular, or smooth and well polished. The edge of the blade is in the middle line, but the sharp curve of the crust surface sometimes produces an adze-like blade. The edge of the blade is gapped on forty-six, and smooth on sixty-two, but it has been flattened by percussion on two specimens.

Although the blade is at the end on all the specimens described in this paper, attention is drawn to split-pebble trimmed coroid tools with a ground lateral blade, commonly called skin-dressers (Thorpe and McCarthy, 1933).

Percussion use.—Sixty have been used for hammering on the butt, and they occur among all varieties. A small number is also battered along one or both lateral margins. Only ten bear percussion marks, and one an anvil-pit, on the upper or lower surface, and they are on the latter or crust surface in most instances.

Materials include sedimentary, igneous and metamorphic rocks of the usual types found among river pebbles; most of them are grey in colour.

Name.—It is proposed that the name *windang* be adopted for this type of axe to simplify reference to it in literature and to define it as a distinctive type among Australian artefacts. It is the name of the entrance to Lake Illawarra, and many axes of this type have been collected on the two kitchen-middens situated on the dunes on the north and south side of the entrance.

Affinities.—The *windang* axe forms a transition between two important phases of stone working in Australia, that in which edge-trimmed implements only were used, and that in which edge-ground tools came into use. It is recorded from Bacsonien sites of the Hoabinhien II culture in Indo-China; the examples figured by Mansuy (1925, Pl. ix, figs. 4*a–b*, from Co-Kho, Pl. xxx, figs. 4*a–b*, from Binh-Long, and Pl. xxiv, figs. 2*a–b*, from Lang-Trang) and by Mansuy and Colani (1925, pp. 25–26, Pl. i, figs. 2*a–b*, 3*a–b*) compare exactly with the Australian specimens, and it is important to note that in Indo-China Hoabinhien I consists of trimmed uniface pebble implements of which the *sumatra*-type is the best known. It might be claimed, therefore, that the *windang* axe represents another link in the chain of evidence supporting a relationship in the pebble industries of Australia and South-east Asia.

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EXPLANATION OF PLATE XVI, FIGURES 1-6.

Fig. 1.—*Windang* axe trimmed at one end, Shellharbour, N. S. Wales. Austr. Mus. Coll. Regd. No. E.34266.

Fig. 2.—*Windang* axe trimmed on one lateral margin, Lake Macquarie, N. S. Wales. Austr. Mus. Coll. Regd. No. E.49513.

Fig. 3.—*Windang* axe, trimmed on both lateral margins and end, Duckmaloi River, N. S. Wales. Austr. Mus. Coll. Regd. No. E.49503.

Fig. 4.—*Windang* axe trimmed all over one surface, Clarence River, N. S. Wales. Austr. Mus. Coll. Regd. No. E.28964.

Fig. 5.—*Windang* axe of split-pebble type, with edge-ground blade at both ends, Cronulla, N. S. Wales. Austr. Mus. Coll. Regd. No. E.28969.

Fig. 6.—*Windang* axe showing plain lower surface, Louth Plains, N. S. Wales. Austr. Mus. Coll. Regd. No. E.44883.

Photos.—G. C. Clutton.

SOME UNUSUAL STONE ARTEFACTS FROM AUSTRALIA AND NEW GUINEA.

By Frederick D. McCarthy.

The Australian Museum, Sydney.

(Plate xvi, figure 7; and Plate xvii, figures 7–12.)

In this paper is described a series of stone artefacts which either possess unusual features or are new forms. They have been acquired from time to time by the Australian Museum.

(1). E.25986. South Wambo, near Bulga, Hunter Valley, New South Wales (Plate xvii, fig. 7).—This remarkable stone club was found by Mr. A. N. Eather on an old camp-site. It is made of a hard, fine-grained granular rock, and its surface is weathered. It is a natural club-shaped stone that has been ground at each end, on both facets, to a bladed or spatulate shape. The broad head, which is 9 cm. wide and 2·5 cm. thick, is rounded on the edges, but has a sharp-edged and rounded end 1·5 cm. wide. The handle tapers from a rectangular cross-section 7 cm. wide at the top, to a sharp-edged blade at the grip end. In shape it resembles bladed wooden clubs, with straight or curved handles, from this area, and it was no doubt utilized by the aborigines for this reason. It is 56 cm. long, and weighs 3 lb. 8 oz.

(2). E.50920. Murramarang, New South Wales (Plate xvii, fig. 8).—A large symmetrical pebble, 20 × 13 × 5 cm., of hard compact sandstone, which bears on one surface three elongate hammer-dressed areas; one is crescentic, the middle one is broad but is narrowed at one end, and the other one is slightly wider at one end than the other. They are indeterminate in shape and significance, but the fact that they are separated indicates that they are representations and not part of the shaping of the pebble in the manner that an axe is made, that is, by hammer-dressing from the blade end as a rule. It was found on a kitchen-midden in 1936 by Mr. M. S. Stanley.

4. E.49633. Glanmire Station, Bathurst, New South Wales.—A narrow, irregular piece of fine-grained shale which has on one surface a series of longitudinal and transverse scratches. Some are lightly and others deeply incised, and among them there are five white lines formed by an inclusion in the stone, but they cut across the longitudinal scratches at a regular and different angle from that of the transverse scratches. It is similar to an example from Mathewson Springs, northern Flinders Ranges, described by Mr. C. P. Mountford (1938, 144, Plate A, fig. 1) in a series from South Australia. It is 10 × 3·5 × 1 cm. Presented by the late Mr. A. E. Ivatt.

5. *Mena.*—This name is proposed for artefacts described by Mr. D. A. Casey (1936). Two of this group, and two more herein described, were ploughed up by Mr. G. Kimlin on newly cleared land on Mena Creek, Cairns district, Queensland, and he has kindly presented examples to the museums in Brisbane, Sydney and Melbourne. They vary in shape from a Y to a triangle, and are difficult to refer to in simple terms in literature. The name *mena*, therefore, is proposed because it is associated with the type historically and geographically.

E.49897. Mena Creek, Queensland (Plate xvii, fig. 9).—A fine example polished all over and carefully shaped. The two surfaces slope inwards at the top. One of the pointed ends is missing, and there are two plough gashes on one margin at the top. The tang has a bladed end which has apparently had a flake broken off as a result of use, and the flake-scar is re-polished; its edge is battered. The top is flat and striated, and there is a deep incised line running from end to end. An interesting feature of this *mena* is a series of very fine scratches on one surface, one group of which is parallel

with the top edge, a second group with an oblique margin, and a third group is transverse; other fine scratches are scattered all over both surfaces. On one edge of the tang there are four deeper incisions 1 cm. long, and on an oblique margin are ten more similar cuts, both sets being transverse. The material is a fine-grained slate. It is 13 cm. long, 17 cm. wide, 1·5 cm. thick, and the tang is 4 cm. wide in the middle; 9 oz. in weight. Presented by Mr. G. Kimlin.

E.49898. Mena Creek, Queensland (Plate xvii, fig. 10).—A crudely made example on which there are patches of both hammer-dressing and polishing. Its flat but undulating top is striated, one corner shows marks of percussion use, and the other corner has a ground facet on one side. The end of the tang is a blade formed by two ground facets each 3 cm. wide, and the edge is heavily battered from use. It is made of an igneous stone, the surface is patinated, and one side bears plough cuts. It is 9·5 cm. long, 14·5 cm. wide, 2·5 cm. thick, and weighs 12 oz.

E.3317. Russell River, Queensland (Plate xvii, fig. 11).—This specimen was apparently the first *mena* found, and it was purchased in 1892. It is triangular in shape. The flat top bears striations. The whole of its surface has been ground on a coarse stone which has left fine scratches on every facet. The narrow end has been broken off transversely. It is lenticular in section and the oblique margins are bevelled. The material is slate. It is 12 cm. long, 10 cm. wide, and 1 cm. thick, and weighs 8 oz. This example differs from other known *mena* in not possessing a tang, and it is the smallest of the series. It was evidently ploughed up because the scratches are all filled with soil.

(6). *Yodda.*—It is proposed that the other group of tanged artefacts described by Casey (1934) be called the *yodda* type to distinguish them from the *mena*. *Yodda* is a locality in Papua from which the type was first described.

(7). *Worimi.* E.50647. Redhead Beach, New South Wales (Plate xvi, fig. 7). This *worimi* has been quartered by a blow off a block of hard, fine grained silicified grit. It tapers from the butt, which is 9 cm. thick, to the trimmed convex distal end, and is triangular in section. The inner face is a cleavage surface, and the outer face, which is slightly convex, is trimmed. It is 19 cm. long, 17 cm. wide, and weighs 7 lb. 8 oz. Thus it is not only the largest *worimi*, but is also one of the biggest knapped and trimmed hand-axes yet recorded in Australia, and was probably a double-handed chopping tool. Found and presented by Mr. P. D. Riddell.

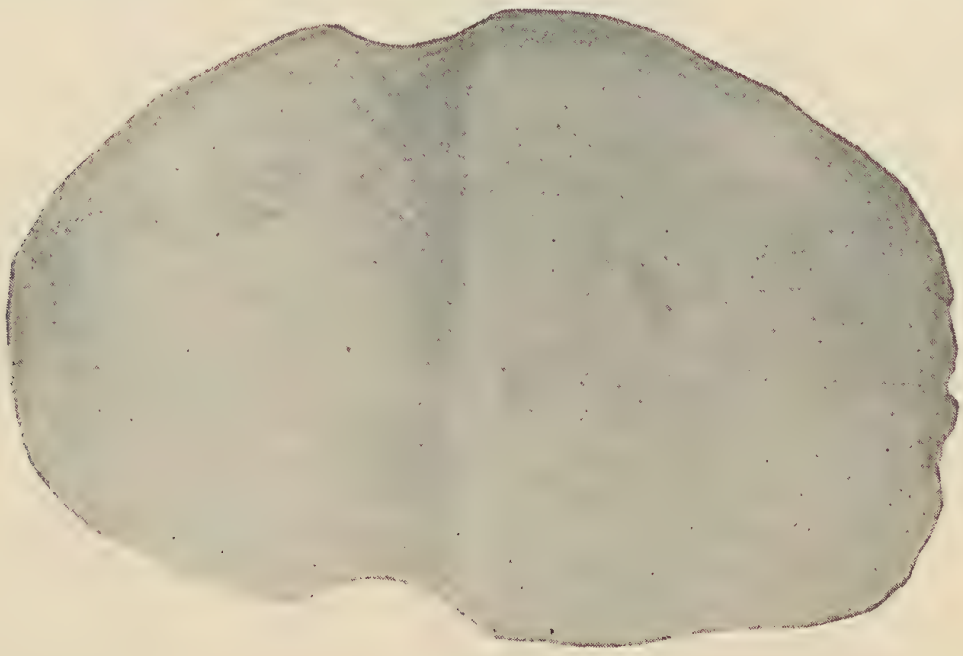

Figure 1.
Grooved axe, Eruru, Keveri Valley, Papua.
(F. E. Williams, del.)

(8). Waisted hammerstone. E.49177. Papua (Plate xvii, fig. 12).—A water-worn pebble of schist, pear-shaped in outline. The two grooves on the lateral margins are 4 cm. wide and 0·5 cm. deep, and were fashioned by hammer-dressing; they do not extend across the upper and lower surfaces. Both ends, especially the butt, bear signs of percussion use. It is 18 cm. long, 8 cm. wide, 4 cm. thick, and weighs 2 lb. 8 oz. The precise locality in Papua in which the specimen was collected is unknown, but it is similar to hafted pebble hammerstones used on Cape York, and it is considered that it is one of latter that has been traded across Torres Strait to the Daudai coast; spear-throwers and spears from Cape York have been collected in this area of Papua (McCarthy, 1939, 179–83, fig. 15).

(9). Grooved Axe (Fig. 1).—Grooved axes are extremely rare in New Guinea, and this specimen was in the collection of the Papuan Government at Port Moresby. The late Dr. F. E. Williams, Government Anthropologist, informed me in a letter written in 1940, that "I had rather a queer find early this year in the Keveri Valley, just north of the Main Range in the Abau district. Walking about the village of Eruru, where I was camping, I saw by chance a grooved celt lying on the ground. It was partly embedded. The ground had been cleared of grass and had been further scoured by rains. No one in the village had noticed the stone, and no one had ever seen an implement of the same sort in use. The oldest man said it was strange to him. The stone implements he had used were of the ordinary plain sort." Remarks attached to the pencil sketch state that the butt end is blunt, and both lateral margins and distal end are ground to an edge; the whole is rough and unpolished. It is 14·5 cm. long, and 9·5 cm. wide. No indication is given as to whether the surface is hammer-dressed.

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EXPLANATIONS OF PLATES.

Plate XVI, Figure 7.

Worimi, Redhead Beach, N. S. Wales. E.50647.

Plate XVII, Figures 7-12.

Figure 7.—Stone club, South Wambo, N. S. Wales. E.25986.
Figure 8.—Pebble bearing hammer-dressed design, Murramurang, N. S. Wales. E.50920.
Figures 9, 10.—*Mena* from Mena Creek, Queensland. E.49897-98.
Figure 11.—*Mena* from Russell River, Queensland. E.3317.
Figure 12.—Waisted hammerstone, Papua. E.49177.

Photos.—G. C. Clutton.

ADZES AND ADZE-LIKE IMPLEMENTS FROM EASTERN AUSTRALIA.

By Frederick D. McCarthy.
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(Plate xvii, figures 1–6; and Figures 1–5.)

Occasional edge-ground adzes have been recorded from scattered localities in Australia, and their existence as a type has been referred to by the author (1939, 4–5, figs. 2 and 8; 1940*b*, 227, fig.), and Noone (1943, 274–5, 279, figs. 10–12, 30–31). In this paper is given a description of the examples in the collection of the Australian Museum.

The chief characteristic of the adze is the asymmetrical blade with its edge above or below the middle; the upper facet is usually rounded, and the lower facet varies from convex to concave and is often at a steep angle. Such implements are hafted, with the blade at a right angle to the haft. The body of the adze varies widely in shape and in Oceania embraces examples with round, lenticular, rectangular, trapezoid, or triangular section.

The axe is the predominant edge-ground implement in Australia; in various collections there are implements with adze-like blades, which, in this paper, are distinguished from true adzes.

Axes with Adze-like Blades.

The examples described below have a distinct adze-like blade, but possess no other adze characters. It is considered probable that in the majority of instances such a blade is fortuitous, and is merely to be considered within the range of axe types in Australia. It does not appear to be due to adze influence, and they should not be termed proto-adzes. The following specimens are described from the Australian Museum collection.

(*A*) *Trimmed coroid axes.*

E.29202. Woodbine, New South Wales.—An irregular piece of igneous stone, crudely flaked on the upper surface, and flat on the lower surface. The blade, which is 5 cm. long, has an upper rounded facet only 1 cm. wide, and a lower adze-like facet 2 cm. wide, with the edge in the middle line. It is 9·5 × 7 × 3 cm., and 12 oz. in weight.

E.13591. Lawn Hills, Queensland (Plate xvii, fig. 1; and Figure 5).—Made from a broad symmetrical flake, with a flat butt-platform. It is trimmed all over one surface. Both lateral margins are sharp-edged, although trimmed in places. The ridges on the upper surface, from the blade to the middle, have been smoothed by grinding, and the facet of the blade is 2·5 cm. wide. Most of the lower surface is polished, and the facet of the blade is 4 cm. wide. It is 8·5 × 8 × 2·5 cm., and 9 oz. in weight. The material is a fine-grained igneous rock.

E.9481. Hamilton Creek, near Mount Fitton, Queensland.—Its upper surface is carefully trimmed from the butt to the middle, and the polished adze-bevel of the blade occupies the other half of the surface. The lower surface is slightly convex and polished. It is lenticular in section, with a carefully trimmed edge on the lateral margins and butt. The material is a fine-grained igneous rock. It is 12 × 9·5 × 3 cm., and 1 lb. 6 oz. in weight.

(*B*) *Hammer-dressed.*

The great majority of adze-like blades occur in the hammer-dressed group of axes. Six specimens, in particular, merit notice in this section. They are from round to oval in section, and several are elongate-oval in shape. They are from 9 to 15 cm. long, and

8 oz. to 1 lb. 8 oz. in weight. They comprise E.18237, 16393, 24327, 24339, 34912, 34946, and are from Condobolin, Coolah, Coolamon, Gooloogong, Kiandra, and Wyalong, New South Wales.

E.15342 is a squat example of cream quartzite from south Central Queensland. The butt is concave but unshaped, and its edges have been used for percussion. There is a wide adze-bevel on its upper surface, but the ground facets are very narrow. The blade is 7 cm. long and is gapped. It is 10 × 9·5 × 4·5 cm., and 1 lb. 6 oz. in weight.

Adzes.

(*A*) *Trimmed coroid type.*

E.49497. Woodstock, Victoria.—A large shoe-shaped implement, flat on both upper and lower surfaces, and rounded along its margins by crude trimming. The polishing of the upper and convex facet of the blade extends for 4·5 cm. from the edge, and on the lower concave facet for 2·5 cm. The lower facet is in the form of a steeply sloping surface 7 cm. long. The edge of the blade curves upward from each margin. The material is a fine-grained metamorphic rock, brown in colour. It is 14 × 9 × 7 cm., and 2 lb. 10 oz. in weight.

Two other examples are rectangular in section. One, E.12739, from Hexham, Hunter valley, New South Wales (Plate xvii, fig. 2), is made from a flat piece of creamy-grey chert, and its upper and lower surfaces are of weathered crust. The butt is trimmed along its upper edge. Both lateral margins have been trimmed, and partially ground to form three long narrow facets on each side; two of the facets on each margin are bevelled, and the middle one is vertical; the section is an irregular octagon (Figure 4). The blade consists of an upper convex adze facet ground 2·5 cm. back from the edge, and a very narrow lower facet only 3 mm. wide. It is 20 × 7 × 2·5 cm., and 1 lb. 4 oz. in weight. H. V. V. Noone has figured three examples of this type from the Napier and Grant Ranges, Western Australia, but they are polished on all surfaces, and are thus purposely fashioned adzes. The Hexham specimen is made of a horizontally layered chert, and this explains to some extent its rectangular section, but does not provide any reason for the adze blade.

E.3596, Darling Downs, Queensland (Plate xvii, fig. 3), is made from a pear-shaped piece of fine-grained brittle rock, water-worn and rolled. At the narrow end is a well polished adze-blade, 2 cm. wide, and the polishing extends 3·5 cm. back from the edge on the lower surface. The butt is a cleavage surface. It is 9 cm. long, 5 cm. wide, 3·5 cm. thick, and 8 oz. in weight.

(*B*) *Hammer-dressed.*

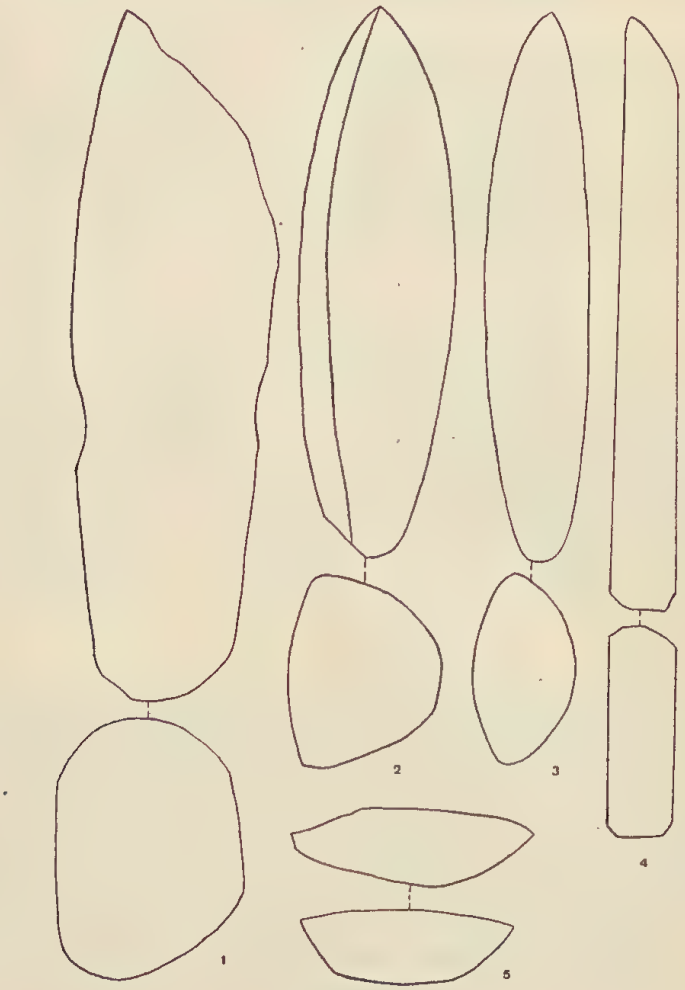
It is to be expected that adzes would be found principally in the hammer-dressed group of edge-ground artefacts, because the technique belongs to the early neolithic period and was employed for the shaping of adzes throughout Melanesia, Polynesia and Indonesia. There are only eleven specimens in the collection.

E.30487. Breeza, New South Wales.—A small adze with a slightly concave facet, 3·5 cm. wide, on its lower surface. The whole of its upper surface is polished. The edge of the blade, which is 3·5 cm. long, is gapped from use, and a large flake is missing from the butt. It bears signs of percussion use on its butt and margins. The material is andesite. It is 6·5 × 4 × 2·5 cm., and 4 oz. in weight.

E.21269. Boggabri, New South Wales.—The upper surface is convex, and the two sides are flat. The lower surface is slightly convex from the butt to the distal end. The blade is 2 cm. wide on both ground facets, and is 3 cm. long. It is made of a fine-grained igneous stone. It is 8·5 × 3·5 × 3·5 cm., and 8 oz. in weight.

E.39591. Myrtleford, Ovens River, Victoria.—A very well finished adze of cylindrical section. The slightly hollowed facet of the lower surface begins 15 cm. back from the edge of the blade, while the upper facet is convex. The grinding is only 1 cm. wide on both facets, and the blade, which is 4·5 cm. long, is continued 3 cm. round the lateral margins. The opposite end tapers to a narrowed ridged butt which has been used for percussion. It is made of an igneous stone, and has a weathered surface. It is 32 cm. long, 7 cm. in diameter, and 5 lb. in weight.

E.8807. Murtee Station, Wilcannia, New South Wales (Plate xvii, fig. 4).—The puncturing all over the surface is very fine, and the shape is distinctly that of an adze in all respects. The lower surface is slightly convex and partially polished, while the upper surface is rounded. It is thus somewhat semi-circular in section (Figure 2), and in this respect it is the same as a high-backed turtle. The blade is 4·5 cm. long, and the ground facets are 1·5 cm. wide. The butt bears percussion marks. It is 19 × 7 × 5·5 cm., and 2 lb. 8 oz. in weight. The material is cream quartzite.



Figures 1-5.
Cross-sections of adzes: 1, Austr. Mus. Coll. Regd. No. E.34143. 2, E.8807. The edges between the lower surface and sides are rounded. 3, E.5266. 4, E.12739. 5, E.13591.

E.2253. Lachlan River, New South Wales.—A red quartzite specimen finished all over with neat and fine puncturing. It tapers from a very broad blade end to a neatly rounded butt. There is a patch of polishing on both upper and lower surfaces. The blade is 10 cm. long, and slightly concave on the lower surface, but it is not ground on either facet. It is one of a group of edge-ground implements which vary from axes to adzes, and from round to lenticular section, found in the neighbourhood of the Darling-Paroo river system. It is 23 × 10 × 6 cm., and 4 lb. 6 oz. in weight.

(C) Hammer-dressed and grooved.

E.37177. Laancoorie, Victoria.—A large heavy specimen hammer-dressed over the whole of its upper convex surface except the butt, which is irregular. There is a marked slope on the upper surface from the groove to the blade. The lower surface is flat apart from a slight upward slope at the blade end. The groove is not central, but is nearer the butt than the blade. The ground facets of the short blade are 1 cm. wide. The material is basaltic. It is 21 × 10·5 × 7 cm., and 5 lb. 8 oz. in weight.

E.34143. Oberon district, New South Wales (Plate xvii, fig. 6; Figure 1).—A large unfinished adze which was described by Thorpe as a pike (Records of the Australian Museum, xviii, 6, 1932, pl. xxix, fig. 3). The upper surface is rounded, and bears a chipped bevel face which extends from the groove to the blade, and a flat crust area between the groove and the butt. The lower crust surface is flat. Thus the blade, which is 6 cm. long, is crust on one facet and trimmed on the other, but was apparently in course of preparation. The central encircling groove is wide and deep. The butt is battered. The material is a dark green quartzite. It is 23·5 × 9 × 5·5 cm., and 5 lb. 8 oz. in weight.

E.49207. Marra Station, Darling River, New South Wales.—Elongate in shape, tapering from the butt to a narrow distal blade. It is flattened on the lower surface, and rounded on the upper surface. The blade is only 2 cm. long, and the ground facets 1 cm. wide; its edge is battered from use. The wide shallow groove encircles the implement. The butt bears percussion marks, and many large flakes have been knocked off it as a result of this usage. The material is silicified tuff. It is 20·5 × 6·5 × 5 cm., and 2 lb. 4 oz. in weight.

(D) Polished.

E.5266. Booligal, Lachlan River, New South Wales (Plate xvii, fig. 5).—This adze was hammer-dressed prior to being polished. It is elongate bi-convex in shape, and bi-convex in section (Figure 3), with a narrow rounded butt that has been used for percussion purposes. The blade is 5·5 cm. long, and the lower facet has a steeper convex curve than the upper one. The edge is sharp. It is one of the finest polished implements from Australia in the Australian Museum collection. It is 19 × 6·5 × 3·5 cm., and 1 lb. 2 oz. in weight.

(E) Polished and grooved.

No. 76 (Australian Institute of Anatomy collection, Canberra). Gundary, Goulburn district, New South Wales.—Although there are no signs of hammer-dressing, it is probable that this technique was used prior to the polishing. One surface has large, rough, natural depressions on both sides of the groove. It is flattened oval in section. There is a thin patination on the surface little different in colour from that of the greenish igneous material of which it is made. The blade has two broad convex facets, and its edge is gapped from use. The opposite end is conical, and the point is polished from use, but is not ground. The groove is 2·5 cm. wide, shallow and polished, and is a deeper colour than the rest of the surface. Two pits caused by percussion are situated between the groove and the blade. This is an exceptionally fine polished artefact, and is much superior in workmanship to the general average of Australian edge-ground implements. It was described and figured (*Mankind*, ii, 1939, 4–5, figs. 2 and 8) by the author as a grooved conical stone because it possesses the characteristics of this group, combined in a unique manner with an adze-blade. It is 25·5 × 7·5 × 5 cm., and 3 lb. 8 oz. in weight.

E.26728. Shea's Creek, Picton, New South Wales.—A similar specimen to E.34143, but it is slightly smaller. It has a hammer-dressed and polished central groove, which is wide and deep, and its lower surface has been similarly treated. The upper convex surface is roughly trimmed, and tapers from the groove to each end. The butt is battered, and the upper facet of the blade is not ground. It is 20 × 8 × 6 cm., and 3 lb. in weight.

Discussion.

Shape.—There is no uniformity in the shape of the adzes described above. The adze-bevel is on the lower surface on the majority. Although the blade is the most important single character for distinguishing adzes, and some examples such as E.3596 possess only an adze blade to merit classification in the group, other characters are to be considered. The turtle-like cross-section of E.8807 and E.34143 and the conical butt end of E.5266 and the Canberra specimen (No. 76) are characteristic of Melanesian adzes.

Techniques.—The majority of the adzes have been fashioned by hammer-dressing, or by hammer-dressing and polishing, and in these respects bear some affinity with many other artefacts in Australia, including axes, grindstones, mortars, percussion stones, the *yodda* and *mena* types of tanged implements, cylcons, and grooved conical stones. The intaglio rock engravings of the interior of Australia are also hammer-dressed.

Affinities.—It is obvious that local variation of workmanship would produce a small percentage of adze-like blades among the immense numbers of axes in Australia, but adzes like E.5266, E.8807 and E.34143 are so different in shape from axes, combining adze blade and form so distinctly, that a comparatively recent ex-Australian cultural influence is denoted. The Melanesian area is the most probable source of this diffusion, and this conclusion is supported by the conical pointed butt on several specimens, a characteristic of Melanesian adzes. In addition, it is now generally considered that the hammer-dressing and polishing techniques were introduced into Australia (McCarthy, 1940*a*, 40–43; 1940*b*, 268) as part of a diffusion of culture from this area over a long period.

Reference might also be made to the three specimens recorded by Davidson (1935, 155, pl. ix, figs. 1–3) from Western Australia. It is considered that they are not of Australian aboriginal manufacture, despite the superior workmanship of such examples as E.8807 and No. 76 (Canberra) described in this paper. They are of three distinct types, each highly developed neolithic forms widely distributed in the eastern Indonesian islands (Celebes, Ambon, etc.), New Guinea and Melanesia, and, in addition to being the only specimens known from Western Australia, are unique among Australian artefacts. It is probable that the aborigines obtained them from Malayan proa traders, Papuan pearl-divers, or even from white people along the north-west coast, and traded them along the pearl-shell routes (McCarthy, 1939*a*, x, 92–95, map 14; 1940*b*, ii, 268; 1940*b*, 43); Noone (1943, 275) has also referred to them as alien adzes.

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EXPLANATION OF PLATE XVII, FIGURES 1-6.

Fig. 1.—Trimmed axe, made from a heavy flake, with adze-like blade, Lawn Hills, Queensland. Austr. Mus. Coll. Regd. No. E.13591.

Fig. 2.—Trimmed coroid adze, rectangular section, Hexham, N. S. Wales. Austr. Mus. Coll. Regd. No. E.12739.

Fig. 3.—Trimmed coroid adze, Darling Downs, Queensland. Austr. Mus. Coll. Regd. No. E.3596.

Fig. 4.—Hammer-dressed adze, Murtee Station, Wilcannia, N. S. Wales. Austr. Mus. Coll. Regd. No. E.8807.

Fig. 5.—Polished adze, Booligal, N. S. Wales. Austr. Mus. Coll. Regd. No. E.5266.

Fig. 6.—Hammer-dressed and grooved adze, Oberon, N. S. Wales. Austr. Mus. Coll. Regd. No. E.34143.

Photos.—G. C. Clutton.

ARENICOLA FROM SOUTH-EASTERN AUSTRALIA.[1]

By Leo W. Stach, M.Sc., F.R.M.S.

(Plate xviii; Figures 1–6; Map.)

This note records the occurrence for the first time on the Australian mainland of the widely distributed southern form *Arenicola assimilis* var. *affinis* Ashworth, the nearest locality from which it has been recorded being at Burnie on the north coast of Tasmania (Ashworth, 1912). Ashworth (1916) also describes four specimens of *Arenicola loveni* from Kangaroo Island and Lacepede Bay (South Australia). The writer and other members of the McCoy Society collected a large series of specimens referable to *A. loveni* during that society's expedition to the Sir Joseph Banks Islands in Spencer Gulf (South Australia) in December, 1936 (McCoy Society, 1937, 1939), thus extending the range of this form further west in southern Australia. The south Australian form of this species merits varietal distinction from the typical South African form as described by Ashworth (1910, 1911).

Arenicola loveni sudaustraliense, var. nov., is one of the dominants of the *Katelysia-Arenicola-Entromorpha* faciation of the sand beach association of the intertidal biome of southern Australia. This faciation is described in detail elsewhere by the writer (Stach, 1944).

Arenicola assimilis Ehlers var. affinis Ashworth, 1903.

A. assimilis var. *affinis* Ashworth, 1903, p. 764; *idem*, 1912, p. 124.

Specimens identical with Ashworth's description and ranging in size between 8 and 17 cm. were obtained in abundance at several localities along the coast in Western Port Bay (Victoria) between Balnarring and Point Leo. In life the trunk is light brown in colour and nearly transparent, the blood vessels being visible through the integument; the tail region is pale green-brown and transparent.

Arenicola loveni sudaustraliense, var. nov. (Figs. 2–6; Plate xviii.)

Arenicola loveni Ashworth, 1916, p. 38.

Descriptive Notes.—The largest of the series of twenty-three specimens examined (and probably the largest specimen of *Arenicola* yet recorded) attains a total length of 560 mm., the trunk being 235 mm. long; the smallest specimen of the series has a trunk length of 117 mm. In life the trunk is deep brown in colour posterior to the first nephridial aperture, while anterior to it the leathery integument is heavily pigmented with black; the tail is light brown. The external characters (Figs. 2, 3; Plate xviii, fig. 1) agree in all particulars with Ashworth's most recent account (1916, pp. 38–41) of the species and need not be discussed further, except to note in one specimen the presence of an additional posterior segment consisting of four small annuli and an enlarged chaetiferous annulus without gills, but with notopodium and neuropodium on the right side only (Figs. 4, 5; Plate xviii, fig. 1).

In the twelve specimens dissected, it was found that in no case did both septal pouches pierce the second septum. In four of these, one pouch pierces septum 2 and the other, like those of the remaining eight specimens, is doubled back from septum 2 towards septum 1 (Plate xviii, fig. 2, *sp*).

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[1] This paper was completed in 1937, but owing to the author's absence from Australia, presentation has been delayed. Circumstances do not permit reference to literature (if any) bearing on *Arenicola* later than 1937.

The globular dilatations of the dorsal blood vessel immediately anterior to the paired hearts, previously noted by Ashworth only in the South Australian specimens (1916, p. 40), are present in all the specimens dissected and vary from 4 to 5 mm. in diameter.

In all species of *Arenicola* known up to the present time the gonads have been found to develop only in association with the nephridia, but in the South Australian specimens there is, in addition to the nephridial gonads, a large gonad (proved by sectioning) developed on the anterior face of septum 3 (Plate xviii, fig. 2, *t*), both septal and nephridial gonads in each individual being of the same sex. Examination of further material from South Africa, collected in the breeding season, may show the same relations in the South African form, but if such is not the case, this feature, together with the development of the dilatations of the dorsal blood vessel and the difference in the arrangement of the septal pouches will necessitate at least varietal distinction for the South Australian form.

Type Material.—Holotype: Fig. 2, Aust. Mus. Coll. Regd. No. W3444. Paratypes: Aust. Mus. Coll. Regd. Nos. W3380, W3445, W3446; National Museum (Melbourne) Regd. Nos. 70806–70814 (inclusive).

Mode of Life.—The large diameter (6 to 8 mm.) of the heaped castings of *A. loveni* readily distinguishes them from those of other sand burrowers. In the inshore lagoons of Moreton Bay (Map) at each low tide, heaps of castings from 7 to 10 cm. in diameter were observed. The mouth of the burrow, which is found about 2 cm. away from the castings, leads to an inclined straight tunnel about 10 to 15 mm. in diameter proceeding downward in a direct line with and away from the castings and the mouth of the burrow (Fig. 1). At a depth of one foot or more the tunnel then becomes horizontal, and proceeding more or less in the same general direction for a foot or two, eventually meanders through the zone of decayed *Posidonia*.

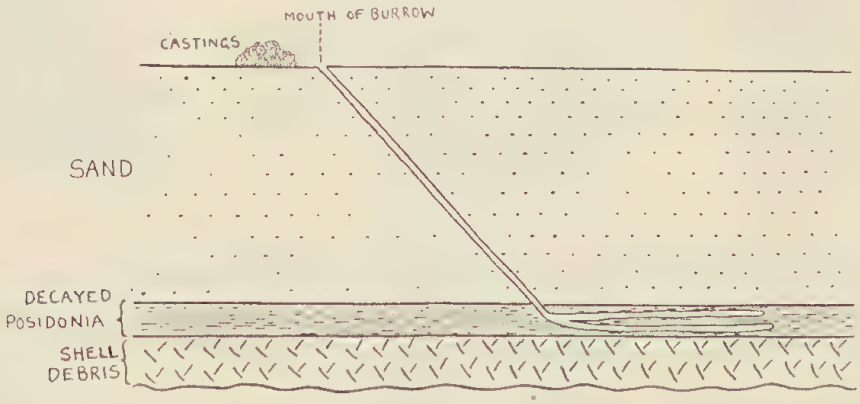
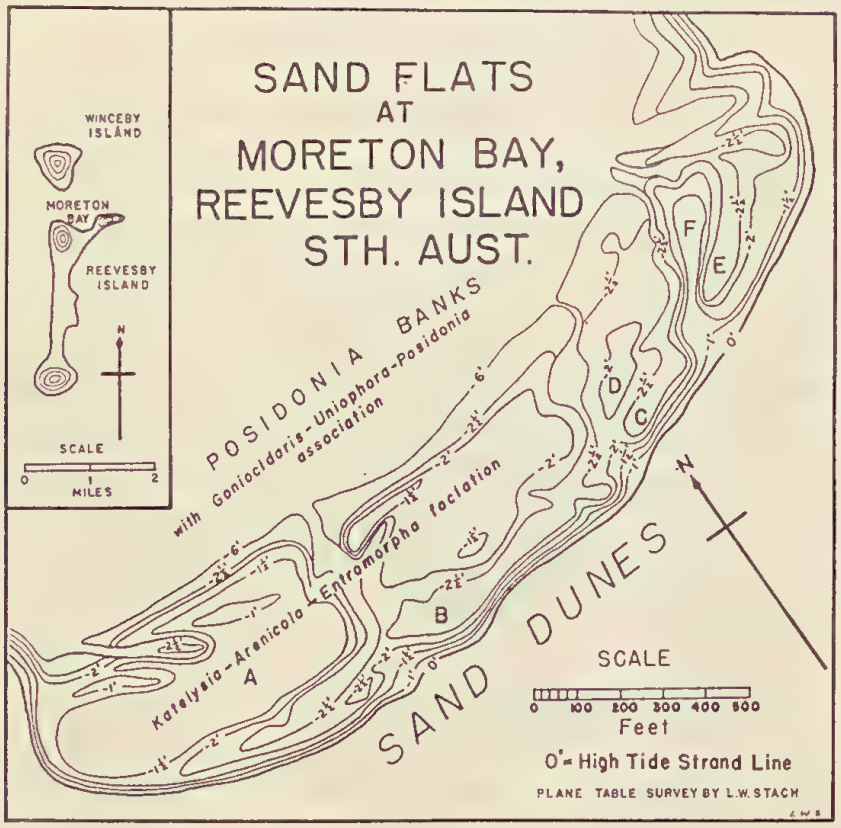


Figure 1.
Burrow of *Arenicola loveni sudaustraliense*.

This consistent arrangement of the burrow greatly facilitated the capture of the specimens. The technique evolved was to dig a short trench about two feet away from the castings, and in a direct line with the castings and the mouth of the burrow. By working towards the castings, the lugworm is met head-on and obtained entire. It was found that following down the burrow with a spade almost invariably resulted in injury to the worm, which moves rapidly down the burrow when the sand is disturbed.

Ecology.—Among the Sir Joseph Banks Islands, *A. loveni* was found only in Moreton Bay, a shallow inlet on the north coast of Reevesby Island. A ridge of sand dunes connecting two low, travertine-capped, granitic outcrops protects the bay from the strong prevailing southerly winds, while the granitic outcrop forming Winceby Island, about one mile north of Moreton Bay, breaks the strength of the north winds, thus affording a great measure of protection from wave action which appears to be a controlling factor of the habitat suitable for *A. loveni*, since, although other conditions were similar, the wide sandy beaches of the east and west coasts of Reevesby Island, which are unprotected from the force of the winds, were destitute of *Arenicola*. The sand

flats of Moreton Bay (Map) are being built up and extended northward by the addition of sand blown from the dune ridges. The wind-blown sand assists in the holding and burial of tidal scour, consisting mainly of the marine angiosperm, *Posidonia australis* J. Hooker, the attrition and decay of which probably provides the bulk of the organic debris upon which the lugworm feeds. The tidal scour is concentrated towards the eastern half of the bay, the western half always being remarkably clean.

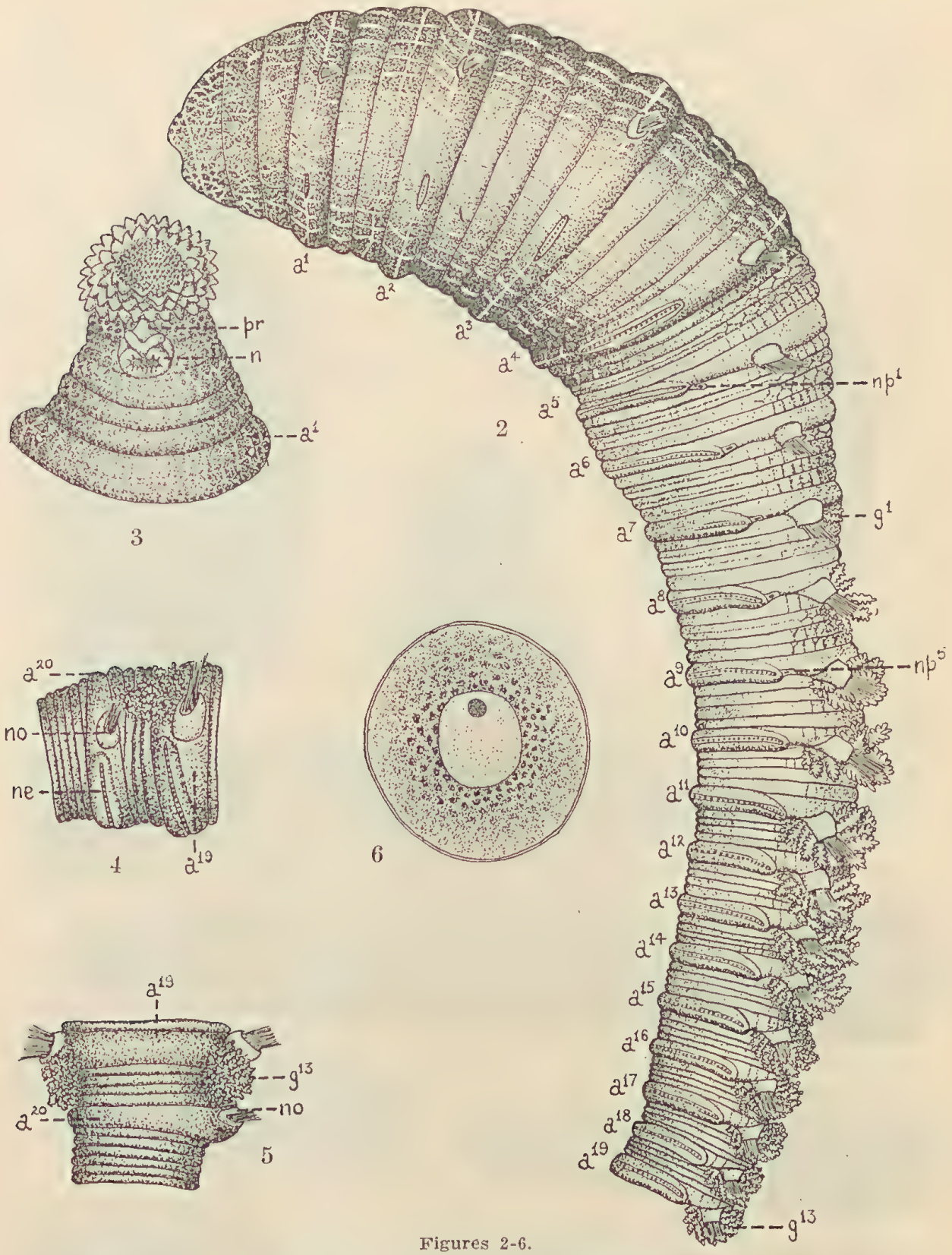


From high-tide mark, the beach slopes regularly and rapidly to the −1′ 6″ contour. Beyond this is a series of shallow inshore lagoons (bounded by the −2′ 6″ contour) separated by low ridges connecting with the barring outer sand flats and emptying by shallow channels with a very gradual fall to the sea at low water. Hayman and Henty (1939, plate x, fig. 1) have published a photograph of portion of Moreton Bay showing the dune ridge with inshore lagoon C in the foreground. As the tide recedes, the water drains out very slowly until, when the tide is fully out, a thin film of water about ¼″ to ½″ deep covers the floors of the inshore lagoons. The broad sand flats barring the lagoons fall within the −1′ 6″ and −2′ contours over the inshore half of their area and fall away regularly and rapidly to low-water mark, at the −6′ contour.

The largest unbroken areas of sand flat occur in the western half of the area (Map, A), most of which rises above the −1′ 6″ contour; no *Arenicola* were observed here. The long lagoon in the western half of the bay (Map, B) had the comparatively sparse population of two *Arenicola* per square yard (estimated by the number of castings over a selected average area of nine square yards), although the sand was more than one foot in thickness.

In the lagoon to the east of this (Map, C) no castings were seen; sectioning revealed 6″ of sand overlying at least 9″ of coarse shell debris (principally composed of valves of *Katelysia scalarina* and *Soletellina biradiata*). Just on the seaward side of this lagoon and within the −2′ contour (Map, D) a section in the sand flat showed 15″ of sand overlying coarse shell debris; here the incidence of castings was about three per square yard.

The next lagoon to the east (Map, E) averaged five to six castings per square yard; a section of this area showed 1′ of yellow-grey sand, followed by 2″ of dark grey-brown,



Figures 2-6.

Arenicola loveni sudaustraliense, var. nov.

Fig. 2.—External features of trunk region. Natural size. (Holotype, Aust. Mus. Coll. Regd. No. W.3444.)

Fig. 3.—Anterior end of trunk showing detail of prostomium and nuchal organ. × 1½.

Fig. 4.—Lateral view of abnormal specimen with a twentieth chaetiferous segment bearing notopodium and neuropodium on the right side, but without gills. × 1½. (Paratype, Aust. Mus. Coll. Regd. No. W.3445.)

Fig. 5.—Dorsal view of additional chaetiferous segment seen in lateral view in Fig. 3. × 1½. (Paratype, Aust. Mus. Coll. Regd. No. W.3445.)

Fig. 6.—Egg from body cavity. × 300. a^1-a^{20}, chaetiferous annuli of segments 1 to 20; g^1, g^{13}, first and thirteenth gills; *n*, nuchal organ; *ne*, neuropodium; *no*, notopodium; np^1, np^5, first and fifth nephridial apertures; *pr*, prostomium.

fibrous decayed organic matter derived from *Posidonia australis*, overlying 5″ of sand passing into coarse shell debris. On the sand flat adjoining this lagoon on the seaward side and falling within the −1′ 6″ contour (Map, F), a section revealed two feet of yellow-grey sand and 2″ of decayed organic matter overlying coarse shell debris. Here the frequency of the castings was only about two per nine square yards.

On the seaward slope of the sand flats, in the eastern half of the bay (Map, G), there is more than 2′ 6″ thickness of sand, the incidence of the castings being two to three per square yard.

From these observations, it is seen that *A. loveni*, despite ideal conditions of food supply and thickness of sand, as is shown by the section of the sand flat adjoining the last lagoon described, occurs very rarely above the −1′ 6″ contour, probably because of the long period of exposure (about six or seven hours every tide) and consequent drying out of the sand between high tides. The controlling factor in this case could not be the greater depth of sand to be traversed before the feeding zone is reached, since a much higher incidence of castings is recorded on the seaward slope of the flats where the sand is more than 2′ 6″ thick.

A determining factor is the depth of sand available for burrowing, as is shown by a comparison of lagoons C and E. From this it is seen that a thickness of at least one foot of sand is necessary before an impassable substratum, such as coarse shell debris or travertine, is reached.

The concentration of tidal scour in the eastern half of the bay is obviously correlated with the much greater incidence of castings in this area. The lagoons of the western half of the bay, although ideal as regards thickness of sand, lack the large amount of organic matter which is found in the sands of the eastern half of the bay and consequently the frequency of *Arenicola* is diminished. On the seaward slope of the sand flats, the much greater thickness of sand and the smaller proportion of organic debris have both probably contributed to the lowering of the incidence of *A. loveni*.

Breeding.—Arenicola loveni was commencing its breeding season at Reevesby Island in December. No young stages were met with, the trunk of the smallest specimen, which bore a well-developed septal ovary, being 117 mm. long. In four of the specimens dissected the septal gonads had not yet shed their products into the body cavity, while in the remainder the body cavity was either packed with masses of bright orange eggs (Fig. 6) varying from 0·10 to 0·15 mm. in diameter, or the coelomic fluid was crowded with sperm.

In the shallow water just beyond the outer limits of the sand flats at low tide numerous long, slender, clavate, gelatinous masses studded with minute red-brown eggs were seen issuing from burrows of the same diameter as those of *A. loveni*, but owing to their being covered by about one foot of water, the sand caved in too rapidly for any actual specimens of the inhabitants of the burrows to be captured. These egg masses, up to two feet long, almost certainly belong to *A. loveni* and agree with the egg masses described for *A. cristata* (Ashworth, 1912, p. 74) as found on the Atlantic coast of the United States, the only other species from which they have been recorded.

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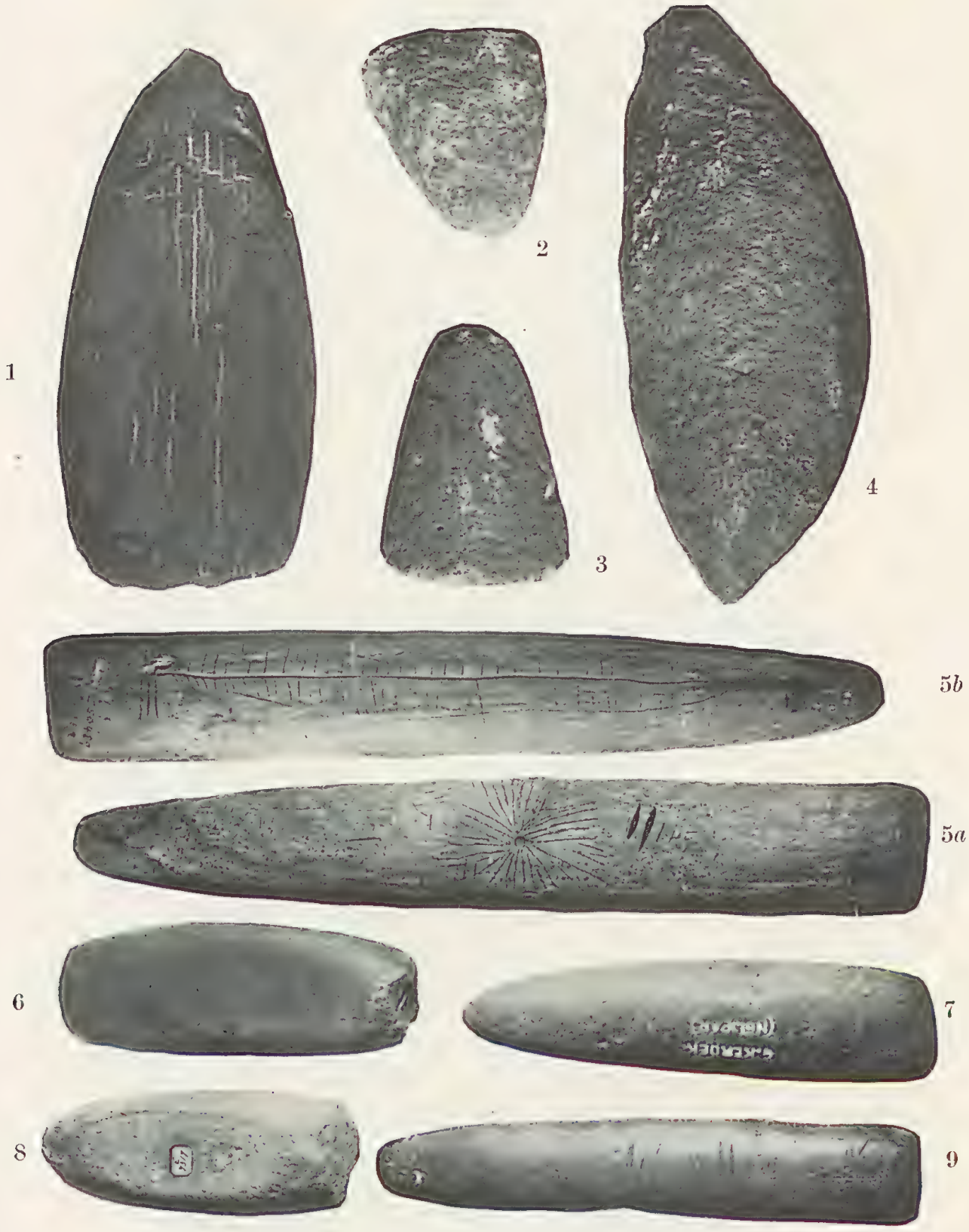
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EXPLANATION OF PLATE XVIII.

Fig. 1.—Abnormal specimen of *A. loveni sudaustraliense* with an additional chaetiferous segment (a^{20}). Approximately natural size. a^{10}, nineteenth chaetiferous annulus; *ts*, tail region. (Paratype, Aust. Mus. Coll. Regd. No. W.3445.)

Fig. 2.—Specimen of *A. loveni sudaustraliense* opened along the mid-dorsal line to show the internal anatomy of the anterior region of the trunk. Approximately natural size. *d*, globular dilatation of the dorsal blood vessel; *dv*, dorsal blood vessel; *h*, heart, *nf*, nephridium; *op*, oesophageal pouch; s^1, s^2, s^3, first, second and third septa; *st*, stomach; *t*, testis on anterior face of third septum. (Paratype, Aust. Mus. Coll. Reg. No. W.3446.)

Photos.—L. Preston.

NATIONAL MUSEUM OF VICTORIA

C. Anderson.

CHARLES ANDERSON:

5th December, 1876–25th October, 1944.

Charles Anderson, youngest son of John Anderson of Moa, Stenness, Orkney Islands, was one of a family of nine. Educational opportunities he forged for himself. From his first school at Stenness he won two bursaries to the Kirkwall Burgh School, from which twice weekly he walked home for supplies, nine miles each way—thirty-six miles weekly. At the Burgh School he acquitted himself so well that he won his way to Edinburgh University, where, by means of scholarship and prize, he pursued his course of study. His career was a brilliant one. He was medallist in every science subject—Chemistry, Crystallography, Geology, Mineralogy, Physics, and Zoology—besides being awarded the Hope Prize Scholarship as the most distinguished student in the Chemical Laboratory. Apart from these awards he obtained distinction in English Literature Latin, and Senior Mathematics, and graduated Master of Arts and Bachelor of Science To achieve this was more than hard work alone; it was hard work performed under hard conditions, conditions which demanded physical strength and tenacity of purpose.

After his graduation he was appointed to take charge of the Ben Nevis Observatory, whence he came to the Australian Museum as Mineralogist. This post he took over on 22nd July, 1901. Almost immediately he applied himself to the task of reorganizing his department, its collections and exhibits—a task which well repaid his labours as those who knew the department previously could testify. Besides these curatorial duties he embarked upon research work in Mineralogy, and for this he was awarded his Doctorate of Science in 1908 by the University of Edinburgh.

In 1911 he visited Europe. The object was a twofold one. He was anxious to see his aging parents, to whom he was deeply attached, and also to study the development of museums and their trends. Following a short interregnum after the death of the late Robert Etheridge, junior, Anderson was appointed Director on 14th February, 1921. It was at this stage that he abandoned mineralogy and crystallography and gave what time his new duties would spare to vertebrate palaeontology, in which field he attained world eminence. He was thus widely known in the scientific world both as a mineralogist and as a vertebrate palaeontologist. During his directorship the Museum developed in many ways. *The Australian Museum Magazine* was founded; more precisely, it was established between the death of his predecessor and his appointment, though the first issue appeared subsequently. To this he contributed many articles upon a wide range of subjects. Popular lectures, begun in 1905, were expanded, though staffing did not permit the full extension hoped for. Gallery displays were improved considerably, and many fine groups were installed. So good were these that they earned the approbation of many overseas authorities. He retired from the office of Director of the Museum on 31st October, 1940.

He was President of the Royal Society of New South Wales (1924), Linnean Society of New South Wales (1932), Anthropological Society of New South Wales (1930, 1931), and the Geographical Society of New South Wales (1941, 1942). He was a foundation member of the Art Galleries and Museums Association of Australia and New Zealand, and a member of the Australian National Research Council. He was also a Corresponding Member of the American Museum of Natural History, New York, and a Corresponding Member of the Zoological Society of London. He was one of the Honorary Secretaries of the Royal Society of New South Wales from 1935 to 1943.

He had an extensive knowledge of the sciences, apart from those he was actively engaged in, and was a good classical scholar and linguist. An ardent Orcadian, he was

steeped in the lore and legends of his native isles, and nothing pleased him more than to tell some folkloristic anecdote of the Orkneys. Many, who had been entertained with these whimsically related tales, when reading Linklater's *White Maa's Saga* later, came across passages with a familiar smack. He was an excellent companion, kindly and friendly, ever ready to help in any capacity. He gave freely of his services and none can say that they approached him in vain. He was a tireless worker, not infrequently working into the wee sma' hours. He was a man of simple tastes. To him a field outing was much more than a collecting trip. To be able to get away to some remote spot, such as Cuddie Springs near Brewarrina, or go trouting on the Goodradigbee, or exploring some new or little known cave, was something to be keenly appreciated. He enjoyed a game of golf, his pipe, and a good book. To those who knew him he was a cordial and sincere friend.

He is survived by a son, Mr. M. S. Anderson, B.V.Sc., and two daughters, Mrs. E. C. Ballek and Miss Margaret Anderson.

His most important contribution to Australian Mineralogy was in the field of morphological crystallography. He published crystal measurements and drawings of some forty-five mineral species from many localities throughout the Commonwealth.

He determined new crystal elements for azurite from his measurements of crystals from Mineral Hill, Condobolin, New South Wales, showing that the axial ratios of this azurite differed from those of the Chessy (France) azurite which was quoted as the standard in most publications. He found that the beautiful and complicated twinning of cerussite from Broken Hill, New South Wales, and Muldiva, Queensland, varied from the true twin position in the same direction as that in crystals from Mapimi, Mexico, and Sardinia previously described by Goldschmidt and Hubrecht respectively.

He paid particular attention to the etched crystals of beryl from Torrington, New South Wales, and obtained similar etch figures by dipping unetched crystals in fused sodium carbonate. In addition he determined the crystal form, optical properties, and discussed the paragenesis and occurrence of the crystals.

Other minerals that he made the subjects of special study were anglesite, cassiterite, cuprite, monazite, orthoclase, topaz, and the zeolites. By these special detailed studies he discovered the following new forms:

Anglesite: Broken Hill, New South Wales, Y(187), X(3·4·12), v and v(598); Dundas, Tasmania, (368).

Azurite: Broken Hill, New South Wales, $x(\bar{4}81)$.

Beryl: Torrington, New South Wales, $\theta(30\bar{3}1)$, $(90\bar{9}2)$.

Cuprite: Mount Lyell, Tasmania, r(405); Linda, Tasmania, B(155), i(307).

Mimetite: Mount Bonnie, Northern Territory, $r(10\bar{1}2)$.

Monazite: Mount Garnet, Queensland, $\sigma(\bar{3}01)$; Olary, South Australia, $\lambda(212)$; Trundle, New South Wales, $\rho(\bar{1}03)$.

Rhodonite: Broken Hill, New South Wales, $A(013)$, $B(0\bar{1}5)$, $C(0\bar{1}4)$, $D(0\bar{1}3)$, $E(0\bar{3}7)$, F(103), G(207), $H(\bar{2}01)$, $K(\bar{1}\bar{1}3)$, and $L(\bar{1}\bar{1}2)$.

Topaz: Pakenham, Victoria, J(501).

Together with H. S. Jevons he established the fact that the so-called "opal pine-apples" from White Cliffs, New South Wales, were really pseudomorphs of opal after crystals of glauberite which were deposited on the bed of the Cretaceous land-locked sea.

The supposed new mineral petterdite, at that time thought to be a new oxychloride of lead, found in the upper workings of the Britannia Mine, Zeehan, Tasmania, was investigated by Dr. Anderson, who proved that the name must lapse into the synonymy of mimetite.

In 1913 he described and analysed the "Binda" meteorite, the only specimen of eucrite to be found in Australia, and in the same year published a catalogue and bibliography of Australian meteorites.

His "Bibliography of Australian Mineralogy", published by the Geological Survey of New South Wales, in 1916, has proved to be of the greatest use to students of Australian mineralogy. In fact, no student of Australian mineralogy can afford to be without it. The work, largely carried out in his spare time, lists the titles of about

one thousand papers, of which not a few are to be found in foreign journals. Only original matter of scientific value was included, and with the thoroughness that always characterized Dr. Anderson's mineralogical work, he laboriously referred to original sources whenever possible.

Anderson was always keenly interested in the study of vertebrate animals of the past. He received an early introduction to the science of palaeontology as a boy in the Orkney Islands, where he made a collection of fish remains from the Old Red Sandstone. His interest was later stimulated by the brilliant lectures on vertebrate palaeontology delivered during his university days at Edinburgh.

On his appointment as Director of the Museum he took charge of the vertebrate palaeontological section and devoted himself wholeheartedly in this new sphere of scientific research. The first years of this new work were occupied mainly with the exacting details of sorting and cataloguing the collection. Much of this was done in the evenings, and night after night Dr. Anderson's enthusiasm kept him in his office until very late hours.

He decided to devote his researches to the Pleistocene mammals of Australia, and in this regard had a particularly sound foundation to work from, as he followed in the footsteps of Richard Owen.

At this time Dr. Anderson became interested in the extinct Chelonian, *Meiolania*. His first palaeontological contribution, published in 1925, was on this genus. He described a new species from Walpole Island, and in great detail and accuracy recorded his osteological researches on *M. platyceps* Owen. In this paper some interesting conclusions were put forward regarding the occurrence and distribution of *Meiolania* and its importance as evidence of continental land-bridges. In 1930 he published additional information gained from specimens of *M. platyceps* Owen collected from a coral-sand formation on Lord Howe Island. From the evidence of several limb-bones of the one turtle he concluded that *Meiolania* was essentially a terrestrial reptile.

In 1926 he carried out an intensive investigation of the Pleistocene cave-earth deposits in the Wellington Caves, New South Wales, and made a large collection of fossil remains. Many of these specimens served as material for his later palaeontological papers.

In 1933 Dr. Anderson achieved one of his ambitions when he organized and superintended extensive excavations at Cuddie Springs, near Brewarrina, New South Wales. He had hoped on this occasion to find some remains of the extinct lizard *Varanus* (*Megalania*) *priscus* Owen, but none were unearthed. He had already described the dentition and several leg-bones of this lizard in 1930 and had become particularly interested in its skull, of which little is known. He concluded that the length of this giant lizard must have been from fifteen to seventeen feet. From his researches on *Megalania* he was able to produce sufficient data to allow a reconstruction of the head to be made and this model is now in the fossil gallery of the Australian Museum.

At the Hobart Meeting of the Australasian Association for the Advancement of Science in 1928, Dr. Anderson read a paper on the food habits of *Thylacoleo*. His theories were advanced after a study of the skull structure and the extraordinary dentition of this so-called Cave Lion. The lack of development of the canines is very significant and a number of theories explaining this character have been propounded. Dr. Anderson described the dentition in detail and suggested that the food was in all probability some vegetable which might have been a member of the family Cucurbitaceae, with a hardened wall and soft pulpy interior. He put forward a suggestion that *Thylacoleo* also fed on the starchy pith of certain cycads such as *Zamia* and *Macrozamia*. His researches on this strange Pleistocene animal were published in the Records of the Australian Museum in 1929.

Dr. Anderson began a much-needed revision of several Macropod genera in 1929. During that year he described a recently discovered and almost complete skull of *Macropus titan* Owen, recording a good deal of additional information regarding its cranial osteology and dentition. Continuing this work he published in 1932 a revision

of the genera *Procoptodon* and *Sthenurus*. During the course of this work he prepared a complete redescription of the skull structure and dentition of *Sthenurus occidentalis* Glauert, from the Mammoth Cave, Western Australia.

At the time of his retirement he had a paper on the revision of the genus *Macropus* nearing completion, and included in it were descriptions of five or six new species. He had hoped to return in his leisure years and complete this work, but unfortunately was unable to do so.

The giant kangaroo, *Palorchestes*, was of special interest to Dr. Anderson, and he was always seeking additional fossil material.

In his Presidential Address before the Linnean Society of New South Wales in 1933, Dr. Anderson gave some indication of the vast knowledge of Australia's vertebrate fossils he had gathered in the few years he was actively engaged in their study.

During this address he carefully described the historical advance of knowledge regarding this fauna and the accumulation of present-day knowledge. He also compiled an extensive bibliography of Australian fossil mammals which is of the greatest assistance to workers in this field.

Dr. Anderson was of the opinion that the fossil mammals of Australia throw little light on the evolution of our present-day mammalian fauna, or their relation to marsupials, living or extinct, in other parts of the world. He concluded that this information could be obtained only when the older Tertiary mammals of Australia, which must have existed in abundance, but are practically unknown, have been found and critically examined.

In 1937 Dr. Anderson recorded the first known remains of fossil marsupials from New Guinea, when he described *Nototherium watutense* from the Watut River district. The remains consisted of two mandibular rami and were collected from beds of Pleistocene age (overlying Tertiary volcanics) or of very late Tertiary age. The importance of this occurrence was the direct evidence of land communication between Australia and New Guinea. Dr. Anderson concluded that the small size of the New Guinea species suggested the possibility of its being an outlying representative of a slightly older fauna which may yet be found in the Australian Tertiary. He was of the opinion, however, that the Australian Pleistocene marsupials and their contemporaries represent a development peculiar to the Australian continent.

The following list includes his more important contributions to Palaeontology:

1925. Notes on the Extinct Chelonian *Meiolania*, with a Record of a New Occurrence. Rec. Aust. Mus., Vol. xiv, 4, pp. 223–242.

1928. The Food Habits of *Thylacoleo*. *Rep. Austr. Assoc. Adv. Sci.*, xix, Hobart, 243–244.

1929. Palaeontological Notes, No. I. *Loc. cit.*, xvii, 1, pp. 35–49.

1930. „ „ No. II. *Loc. cit.*, xvii, 7, pp. 309–316.

1932. „ „ No. III. *Loc. cit.*, xviii, 7, pp. 383–387.

1937. „ „ No. IV. *Loc. cit.*, xx, 2, pp. 73–78.

1933. The Fossil Mammals of Australia. *Proc. Linn. Soc. of N.S.W.*, lviii, ix–xxv.

Note.—This account of Dr. Anderson and his work has been compiled from notes prepared by Messrs. W. A. Rainbow (Librarian), T. Hodge-Smith (Mineralogist) and H. O. Fletcher (Palaeontologist).—Ed.

THE LATE GEORGE SMITH.

The late George Smith (1861–1944) was an inveterate collector, and fortunately for the mineralogy of New South Wales his particular forte was the collecting of minerals. In addition, he was a keen observer and most interested in the occurrence, paragenesis, and origin of the minerals he collected.

A native of South Australia, he commenced his career in 1877 with the English and Australian Copper Mining Company, first at Port Adelaide, then as Manager at Waratah, New South Wales, and finally as ore buyer and assayer at Broken Hill in the same State.

In 1890 he resigned his position to become Assistant Manager of the Australian Broken Hill Consols Mine, and four years later he rose to the position of General Manager. In 1898 he left Broken Hill to become Mining Manager for the Chillagoe Mines and Railway Company, Queensland. In 1904 he was appointed as Inspector of Mines, Department of Mines, New South Wales, a position he held until his retirement in 1925.

Throughout his whole life he had always been in a position to indulge to the full his love of mineral collecting. Perhaps his most important additions to our knowledge of Australian mineralogy were made during the years he spent in Broken Hill. First as ore buyer and assayer he had ready access to the mines in the outlying districts, then as Manager of the Broken Hill Consols Mine he had the opportunity of close study of the minerals of that mine as well as inspecting all interesting mineral occurrences in the mines of the Main Broken Hill Lode.

In 1931, Smith prepared a list of minerals found at Broken Hill, giving the place and approximate date of their discovery and the name of the person who first determined them. From that list it would appear that he himself was responsible for making the first determination of the following minerals:

Almandite	Near Pinnacles	1888
Argentite	Consols Mine	1891
Arsenopyrite (cobaltiferous)	Consols Mine	1891
Atacamite	Umberumberka East Mine	1888–9
Aurichalcite	Consols Mine	1890
Barite	Atlas Mine, Purnamoota	1890
Bournonite	Consols Mine	1890–1
Brochantite	British Mine	1888
Chalcotrichite	South Mine	1888–9
Chenevexite	Consols Mine	1890
Chrysocolla	Proprietary Mine	1887
Cobaltite	Consols Mine	1891
Covellite	East Consols Mine	1892
Cuproplumbite	Do.	1892
Dyscrasite	Consols Mine	1890
Erythrite	Do.	1890–1
Harrisite	Proprietary Mine	1897
Iodembolite	Do.	1892
Jamesonite	Lady Carrington Mine, Apollyon Valley	1888
Kermesite	Consols Mine	1895
Melaconite	South Mine	1888–9
Molybdenite	Consols Mine	1890
Phosgenite	Do.	1890
Proustite	(?)	1890
Pyrargyrite	Consols Mine	1890
Rhodonite	Proprietary Mine	1889
Smaltite	Consols Mine	1890–1
Spessartite	British Mine	1888
Stephanite	Consols Mine	1893
Sternbergite	Do.	1892
Stibnite	Do.	1892
Stilpnomelane	Do.	1895
Sulphur	Do.	1890
Tetrahedrite	War Dance Extended Mine, Purnamoota	1888
Tremolite (in galena)	Near Silverton	1888
Willyamite	Consols Mine	1893
Wollastonite	East Consols Mine	1892–3

This list by no means tells the whole story, because had it not been for the keenness of Smith and his associates many of the rarer minerals of Broken Hill, such as raspite and miersite, would probably never have been known.

There seems to have been a comparative lull in his collecting during his association with the Chillagoe Mines. However, during his twenty-one years as Inspector of Mines, he made very extensive collections, particularly in the New England district of New South Wales. Further, he has added a great deal to our knowledge of the mineralogy of this district, particularly in regard to the tin and wolfram deposits. Many very beautiful and rare specimens would have been lost but for his assiduity. He was really an artist as well as a collector, and seems to have had an uncanny ability of detecting symmetry and composition in a mineral specimen. His best specimens were kept in four upright cases, but they only remained there until he secured a better specimen, when they were relegated to his cabinet of drawers to be exchanged for some specimen that he really wanted.

The late G. W. Card, formerly Curator of the Mining and Geological Museum, Sydney, said that on Mr. Smith's retirement he started to make a rough list of the acquisitions directly due to him but gave up the job as "too laborious".

Dr. W. F. Foshag writing from the Smithsonian Institution, Washington, U.S.A., to Mr. Smith, said: "In arranging the collection [of Colonel Roebling—T.H.-S.] I have often remarked upon the fine specimens he received from you and I believe his Broken Hill material is unsurpassed in this country." Colonel Roebling was America's number one collector and it was but natural that he and Mr. Smith should have enjoyed many years of friendship, though they never actually met.

The collection of the Australian Museum contains all his most precious specimens, those with which he would not part until he could no longer take an active part in mineral collecting. It was then, and only then, that he saw them safely housed in the State collection, where they will always remain a tribute to his artistry, ability, and enthusiasm.

Of the many private collections I have seen, it is surprising how many contain one or more labels with the familiar handwriting of George Smith. In many collections those were the only labels. Incidentally Mr. Smith's thoroughness in numbering each specimen, entering it into a register with full particulars, as well as putting a label with the specimen, might, indeed should, be copied by every mineral collector. His register ran into two volumes which are now housed in the library of the Australian Museum.

In 1942 he was awarded the Insignia of the Legion of Honour of the American Institute of Mining and Metallurgical Engineers after fifty years' continuous membership.

It is most fitting that his technical library, including his own works, has gone back to Broken Hill. Presented to the Zinc Corporation Limited, it occupies a proud place in their library.

While he was not a prolific writer, no student of Australian mineralogy is properly equipped without access to his papers, of which a bibliography is appended.

In his younger days he was a cricket enthusiast, specializing in bowling. Among his papers is a score sheet of a cricket match between Woodville and S.W.C.C. dated 14 November, 1882, in which it is recorded that he took eight wickets for thirteen runs including the coveted "hat trick".

He also collected autographs and postage stamps. During the First World War he was very proud of the fact that he had secured the autographs of all the leading figures on the side of the Allies in that great struggle.

In spite of his many years of constant association with the miner and fossicker, he always maintained a courtly old world manner, and though intolerant of carelessness, particularly in specimen labels, he was always ready to help the beginner both from his store of knowledge and his store of specimens.

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A Contribution to the Mineralogy of New South Wales. *Geol. Surv. N.S.W., Min. Res.* 34, 1926, 1–145.

The Lightning Ridge Opal Field. (Govt. Printer, N.S.W., 1929.)

Notes on the Mineralogy of the Silver-Lead-Zinc Deposits of New South Wales, with special reference to the Barrier Ranges Silver Field. *Roy. Soc. N.S.W., Journ. and Proc.*, lxiv, 1931, 224–263.

In addition to the above papers he contributed to the discussions on papers appearing in the *Transactions of the Australasian Institute of Mining and Metallurgy* and the *Transactions of the American Institute of Mining Engineers.*

T. Hodge-Smith.

NOTES ON AUSTRALIAN CERAMBYCIDAE, VII.

By Keith C. McKeown, F.R.Z.S.,
Australian Museum, Sydney.

(Figures 1–6.)

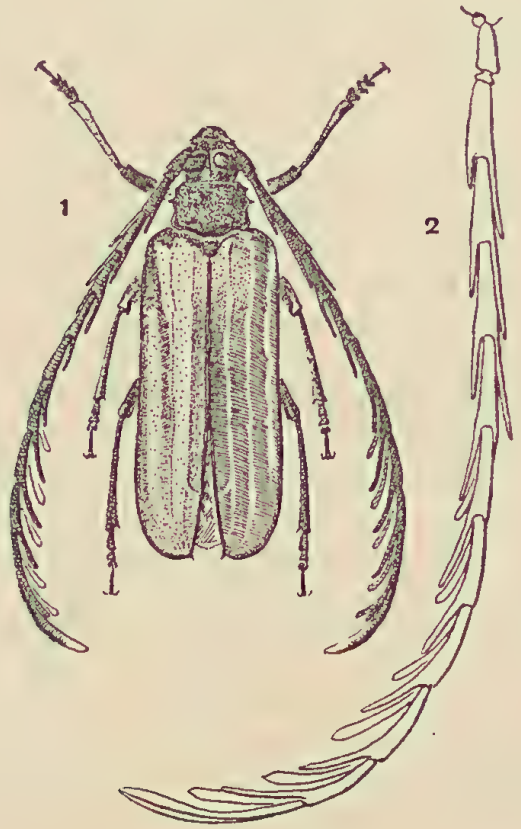
Gen. Eboraphyllus nov.

Characters as in *Enneaphyllus* Waterhouse, 1877, but differs in the spined elytral apices, and the antennary joints bearing two apical foliations in the male.

Genotype, *E. middletoni*, sp. nov.

Eboraphyllus middletoni sp. nov. (Figs. 1–2).

Male. Robust; light brown, thorax pitchy, legs and antennae chestnut-brown. *Head* relatively small, coarsely and confluently punctate; mandibles moderate, black, with sparse coarse punctures; palpi yellow; eyes large, approximate, coarsely granulate, black; antennary tubercles prominent, coarsely punctate basally, apically nitid. Antennae (Fig. 2) considerably longer than body. Each joint bears two apical expansions, becoming longer, more flattened and foliate on each successive segment except the terminal, the inner being the longer in each case; the apical joint terminates in an elongate, slightly thickened leaf-like expansion twice the length of the joint. Joint 1 short and stout, shorter than 3, 3–11 of equal length. First and second joints coarsely and sparsely punctate, the remainder very finely and confluently punctate (shagreened). *Prothorax* wider than long, narrower than elytra, coarsely and confluently punctate, clothed with sparse, erect, stramineous hair, laterally sinuate with a slender acute spine a little anterior to half-way; anterior angle produced into a slightly projecting, some-



Figures 1 and 2.

what flattened tooth; posterior angles rounded. *Scutellum* small, posteriorly rounded, coarsely punctate, with a few sparse hairs. *Elytra* subnitid, smooth, sub-hyaline, finely and sparsely punctate on shoulders, elsewhere with a slightly shagreened appearance; light brown, margin dark and pitchy throughout, exteriorly strongly marginate; three weak longitudinal costae, the exterior strongest and of rounded contour, not reaching to apex; shoulders rounded, apically acutely spined on sutural angle, exterior angle broadly rounded. *Legs* sparsely clothed with yellow hairs and densely fringed with hairs along posterior edge; tarsi narrow, lighter in colour, pads well developed, yellow; 4th joint of tarsus as long as preceding three together. *Ventral surface*: thorax very finely punctate, densely clothed with golden-yellow hair; abdomen subnitid, shagreened; lateral depressed areas on each segment anteriorly with traces of short yellow hair or pile. Long 39 mm.; broad 13 mm. Antennae: long 55 mm.

Female unknown.

Hab.—New South Wales: Ebor, 4,500 feet (Dr. B. L. Middleton), 22 January, 1944. Taken at light.

Holotype (unique) (K67640) in Australian Museum, Sydney.

It is rarely that a worker now has the opportunity of describing as new a large and striking species of Cerambycid, new forms being usually small and inconspicuous. It is even more satisfactory when such a species is a member of a group poorly represented in Australia—the Anacolini Lameere. I am indebted to Dr. B. L. Middleton, of Murrurundi, New South Wales, for this fine species, of which he tells me, he secured three specimens—all males—which were attracted to the light.

The Prionid Group Anacolini Lameere, Sub-group Tragosomae Lameere, contains three Australian genera—excluding the present new genus—*Enneaphyllus* Waterhouse, 1877, *Rhipidocerus* Westwood, 1842, from the mainland, and *Howea* Olliff, 1889, from Lord Howe Island. Each of the genera contains one species only. The Group also includes the well-known New Zealand genus *Prionoplus* White, 1843.

Genus Nungena McKeown, 1943.

When I erected the genus *Nungena* to accommodate the remarkable little species *N. binocularis* McKeown (Rec. Aust. Mus., xxi, 2, 1942, p. 96) I was unable to indicate its systematic position. I now find that it is very closely allied to *Tetraommatus* Perroud, 1855, in which the eyes are similarly divided, and is similar in general facies to the Australian insect. The genus *Tetraommatus* has a range through southern India, Ceylon, Burma, and the Malay Archipelago, and is included in the Group Oemini Lacordaire. The only other genus in the Group Oemini recorded from Australia is *Xystrocera* Serville.

It is possible that *Nungena* may prove to be a synonym of *Tetraommatus*, although there is a marked difference in the antennary formula and in other characters, but it is impossible to determine whether these are of sufficient importance for generic distinction without access to the Indian and Malayan species. It appears inadvisable to make a change without comparison with this material. *Nungena binocularis* appears to be very distinct from any of the described species of *Tetraommatus*. *T. filiformis* Perroud is figured by Gahan (Fauna of British India: Coleoptera I, Cerambycidae, p. 101).

Ochyra coarctata Pascoe, 1871, var. polyrhachis nov.

Specimens of *Ochyra coarctata* Pascoe from the Blue Mountains, New South Wales, are so distinct from the typical form that varietal status appears to be required. A large series from Tasmania (the type locality) and material from Fern Tree Gully, Victoria, have the pubescence over the posterior portion of the elytra almost or wholly black, sparse and closely recumbent, but in the variety this is longer, thicker, less recumbent, and of a shining golden colour, and forms a very conspicuous feature. There is no essential structural difference from the typical, except that in the variety the thoracic spines are more acute and the elytral crests higher and narrower. The type (K67641) from the Blue Mountains (A. Musgrave, 1 October, 1915) is in the Australian Museum, Sydney.

The variety *polyrhachis* bears an amazing resemblance to the ant *Polyrhachis ammon*. I am not aware whether this resemblance is purely accidental or whether it serves any useful purpose in the insect's economy. It would be of interest if it could be observed whether these beetles are in any way associated with ants of the genus *Polyrhachis*, since, like so many other instances of resemblance between forms of widely separated Orders, the value, if any, is obscure.

Genus Austrosomatidia nov.

Characters similar to *Somatidia* Thomson, 1864, but differs in the form of the antennae, which are short and stout, reaching to about one-third of elytral length from base; basal joint stout and cuneiform, 3rd joint twice as long as 4th, remainder decreasing progressively in length. Coxae less abruptly clavate.

Genotype, *A. pulleni*, sp. nov.

Austrosomatidia pulleni sp. nov. (Fig 3).

Robust. Dark brown varied with irregular patches of creamy-brown on prothorax and elytra, nitid, clothed with long erect hairs. *Head* large, broader than prothorax at base, rugose, closely punctate, punctures large and deep; eyes large and coarsely

Figure 3.

granulate; antennary tubercles scarcely evident; head produced into an obtuse angle or tubercle above insertion of antennae; genae swollen; mandibles black; palpi yellow, terminal joint broad, pointed. *Antennae* short and stout, not reaching beyond anterior third of elytra, densely clothed with hair; basal joint broad, cuneiform; joint 2 large, somewhat ovate, 3 twice as long as 4, succeeding joints progressively shorter, with a moniliform appearance. *Prothorax* as broad as long, sides regularly rounded, nitid, coarsely and irregularly punctate, punctures large and deep, clothed with long erect hairs; a fine longitudinal raised line extending from base to one-third based on a pale impunctate area, with a few small, scattered pale areas anteriorly and laterally of this; not marginate basally or apically. *Scutellum* large, rounded, coarsely punctate. *Elytra* elongate-ovate, broadest at about two-thirds, nitid, coarsely and irregularly punctate, punctures large, deep, and clearly defined; two small pale areas at base close to suture, below them two large somewhat rounded pale areas coalescing on suture and varying in intensity, reaching to about half-way; two smaller, irregularly rounded paler patches

coalescing at about two-thirds, and below these a number of small irregular pale spots; pale areas not nitid; apices narrowly rounded, clothed with long erect, but somewhat backwardly inclined pale hairs. *Legs* stout, brown, moderately coarsely punctate, sparsely clothed with long pale hairs and fringed with hair below, broadly but not abruptly clavate; tarsi broad, creamy-yellow. *Ventral surface* sparsely, irregularly, and coarsely punctate. Abdomen dull, with a somewhat lunulate patch of long, pale, recumbent hairs on each side and a few scattered recumbent hairs along posterior margin, except for terminal (5th) segment which is sparsely hairy throughout. Long 7 mm.; broad 3 mm.

Hab.—New South Wales: West Tenterfield (Roy Pullen), 2 April, 1943.

Holotype (unique) (K67642) in Australian Museum, Sydney.

This small species bears a very close general resemblance to *Somatidia*, but may be readily distinguished by its more robust form, the short and stout antennae and their marked difference in the length-sequence of the antennary joints; also in the coxae being thickened and clavate almost from the base, and not swelling abruptly from the peduncle. These characters, I consider, necessitate the erection of a new genus for the reception of the species. This new genus must be placed close to *Somatidia*.

The stronghold of this group is New Zealand, and several species of *Somatidia* occur on Lord Howe Island. Two small species, *S. australasiae* Carter and *S. pernitida* McKeown, occur on the Australian mainland on the southern and northern coastal areas of New South Wales respectively; the present species extends the range of these closely related genera further inland.

The terminal joints of both antennae in this specimen are damaged, and appear to have been partially eaten by some insect.

The unique specimen was collected by L.A.C. Roy Pullen, of the Royal Australian Air Force, and generously presented by him to the Museum. He informs me that it was taken crawling on the ground at West Tenterfield. It is named for the collector in appreciation of his keenness in collecting Australian Coleoptera, and in acknowledgement of many fine specimens received from him.

Genus Tilloforma nov. (Figs. 4–5).

Medium sized insects, moderately robust. Antennae slender, basal joint stout, apically thickened. Prothorax convex, strongly ovate, constricted posteriorly. Elytra parallel sided, shoulders prominent, apices rounded, unarmed. Legs stout, femora very strongly petiolate-clavate.

Genotype *T. moestula* White, 1855.

The genus *Tillomorpha* was erected by Blanchard in 1851 to accommodate *T. lineoligera* as its genotype; subsequently a number of American species were

Figures 4 and 5.

associated with it, and in 1855 White included the Australian species, *T. moestula*. In 1918 A. M. Lea added two further species, *T. mediofasciata* (Fig. 4) and *T. mirogastra*. These Australian species bear only a superficial resemblance to the Chilean genotype, and it appears to be reasonable that they should be separated from *Tillomorpha*. Blanchard's original definition of his genus (in Gay, Historia Fisica y Politica de Chile) is not readily available, so it is quoted here; it reads: "Corpus gracile. Caput oblongum. Mandibulae breves, sat crassae. Palpi cylindrici, crassi, apice truncati. Labium breve, membranaceum, emarginatum. Antennae gracilis, corpore breviores, filiformes, articulo primo gracili elongato, tertio longo, quarto breviore, quinto tertii longitudine, alleris, gradatim brevioribus. Prothorax angustus, sat elongatus, convexus, postice coarctatus. Elytra angusta, apice rotundata, humeris rectangularibus. Pedes, femoribus clavatis, tibiis simplicibus." Blanchard gives a fine coloured figure of the genotype (Atlas, pl. Coleoptera 29, figs. 4–4*f*) which shows that the prothorax is almost parallel sided and very abruptly constricted posteriorly; the femora are shown as narrowly clavate. If this were not sufficient, a wealth of anatomical detail is included in finely drawn supplementary figures; one of these showing the antenna depicts the basal joint as extremely elongate and slender, expanding slightly at the point of attachment, but not broadening apically (Fig. 5). In the Australian species attributed to this genus the femora are extremely broad on the clavate portion and contract abruptly into an extremely slender peduncle; the basal joint of the antenna is stout and strongly thickened to the apex and the prothorax is certainly not "angustus". These characters should serve to distinguish the Australian species, now placed in *Tilloforma*, and justify their separation. Blanchard's figures of *T. lineoligera* and *T. moestula* Lea (copied) are reproduced herewith.

A new species of *Tilloforma* is described hereunder.

Tilloforma bicolor sp. nov. (Fig. 6).

Moderately robust; black banded with white. *Head* broad, narrower than prothorax at widest, with a deep longitudinal groove between the eyes, lightly clothed with recumbent white hair; eyes coarsely granulate; antennary tubercles large, laterally deflected; palpi deep orange-yellow. *Antennae* slender, longer than body; basal joint stout, broadened to apex, finely and closely punctate, joint 3 longer than 1 and 4,

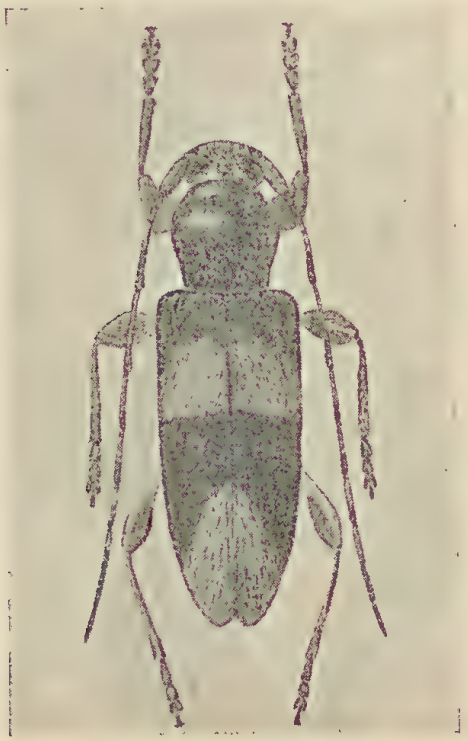


Figure 6.

5 shorter than 4, 6 shorter than 5, succeeding joints progressively shorter, apical joint slender, somewhat pointed. The whole of the antennae closely and finely punctate, densely clothed with semi-erect hairs and close whitish pile, each joint apically banded with black. The colour of the antennary joints varies somewhat according to the angle of view, and the way in which the light catches the pilose clothing. *Prothorax* black, nitid, finely and closely punctate, strongly convex, sides evenly rounded, posteriorly constricted gradually, strongly emarginate; disc nitid, finely and closely punctate, with sides and base lightly clothed with recumbent white pubescence. The central naked portion of the disc may possibly be abraded. *Elytra* wider than prothorax at base, parallel sided but contracting gradually over posterior third to apices which are narrowly rounded; shoulders rectangular, prominent; a broad white band crossing elytra, with its posterior margin at about half-way, and anteriorly reaching almost to base of elytra, posterior demarcation straight, anterior rounded upon each elytron, giving the pale area a B-shaped form which extends across both elytra and reaches the lateral margins; an elongate oval white patch extending from about one-fourth elytral length to apices; pale areas sharply defined and clothed with chalk-white recumbent pile, dark areas clothed with black. *Legs* stout, clothed with pale pile, femora strongly pedunculate-clavate, clavate portion brown, peduncle creamy; femora and tibiae finely punctate; tarsi densely clothed with pale hair, fore tarsi broad, middle medium, hind narrow. *Ventral Surface*: Thorax finely and closely punctate, densely clothed with fine brownish pubescence; abdomen finely and closely punctate, basal segment densely, and succeeding segments (except apical) lightly, clothed with brownish pubescence; apical segment naked, nitid. Long, 5 mm.

Hab.—Queensland, Cairns. Holotype (unique) (K67643) in Australian Museum, Sydney.

Synonymy.

The following names of genera of Cerambycidae represented in Australia are preoccupied, and their renaming has, in consequence, been necessary. I must acknowledge my indebtedness to S. A. Neave's "Nomenclator Zoologicus" for considerable assistance in this work, especially in a few instances where it has been impossible to consult the original reference because the works are not available in Australia.

Acrogenius Blackburn, 1896 (*Trans. Roy. Soc. South Australia*, xx, p. 38), is preoccupied by *Acrogenia* Hall, 1883 (*Trans. Albany Inst.*, (10), p. 193)—Bryozoa. I propose *Acrogenoides* as a new name for this genus.

Agapete Newman, 1845 (*Zoologist*, iii, p. 1017) is preoccupied by *Agapete* Huebner [1825] (*Catal. Franck.*, p. 98), a new name for *Agapeta* Huebner, 1822 (*Syst.-alphab. Verz. Schmett.*, pp. 58–66)—Lepidoptera. *Proagapete* n.n.

Blax Thompson, 1860 (*Classif. Ceramb.*, p. 22), is antedated by *Blax* Koch, 1840 (in Herrich-Schaffer in Fuernrhohr *Fauna Ratisbon*, iii, p. 359)—Collembola. I propose *Blaxotes* as a new name for this genus.

Didymocentrus Aurivillius, 1917 (*Ark. f. Zool.*, x, Nr. 23, p. 45), preoccupied by *Didymocentrus* Kraepelin, 1905 (*Zool. Jahrb. Syst.*, xxii, p. 342 (note))—Arachnida. *Didymocentrotus* n.n.

Diotima Pascoe, 1859 (*Trans. Ent. Soc. Lond.*, (2) v, p. 57), is predated by *Diotima* Reichenbach, 1854 (*Journ. Orn.*, i, Extraheft Beil (Aufz. Colibri), v, p. 12)—Aves. *Pseudiotima* n.n.

Elasmostoma Olliff, 1890 (Rec. Aust. Mus., i. p. 73), preoccupied by *Elasmostoma* de Fromental, 1860 (*Mém. Soc. linn. Normandie*, xi, No. 2, p. 42)—Porifera. *Elasmotena* proposed new name.

Exaereta Pascoe, 1865 (*Journ. Ent. Lond.*, ii, p. 368) is predated by *Exaereta* Huebner [1820] (*Verz. bekannt Schmett.*, (13), p. 200)—Lepidoptera. *Exaeretiformis* is a new name for this genus.

Myrsus Lacordaire, 1869 (*Hist. Nat. Ins. Gen. Coll.*, viii, p. 386), is preoccupied by *Myrsus* (n.n. pro *Metis* Adams, 1857) Adams, 1858 (*Gen. Rec. Moll.*, ii, p. 660)—Mollusca. *Myrsellus* n.n.

Sidis Pascoe [1866] (*Journ. Linn. Soc. Lond., Zool.*, ix, 1868, p. 93) is preoccupied by *Sidis* Mulsant, 1850 (*Ann. Soc. Agric. Lyon*, (2) ii, p. 975)—Coleoptera Coccinellidae). Proposed new name *Sidellus*.

Sodus Pascoe, 1865 (*Trans. Ent. Soc. Lond.*, (3), p. 137), is preoccupied by *Sodus* Amyot, 1846 (*Ann. Soc. ent. France*, (2) iv, p. 77)—Hemiptera. *Similosodus* n.n.

Stenoderus Audinet-Serville, 1835 (*Ann. Soc. ent. France*, iv, p. 210), is preoccupied by *Stenodera* Escholtz, 1818 (*Mém. Acad. imp. Sci. St. Petersbourg*, vi, p. 469)—Coleoptera (Cantharidae). *Stenocentrus* n.n.

A NEW GENUS *GLYPTOLEDA* AND A REVISION OF THE GENUS *NUCULANA* FROM THE PERMIAN OF AUSTRALIA.

By H. O. Fletcher,
The Australian Museum, Sydney.

(Plates xix–xxii.)

Introduction.

In this paper the genus *Nuculana* occurring in the Permian rocks of Australia is revised. Generic rank is given to a well defined group of these shells with a characteristic and bizarre ornamentation under the name *Glyptoleda*. The stratigraphy of the Silverwood-Lucky Valley Permian succession has been reinterpreted on additional palaeontological evidence.

A collection of fossils from Permian beds in the Springsure area of Queensland was made some time ago by Mr. J. H. Reid, of the Queensland Geological Survey. The specimens are of particular interest and include a series of well preserved shells (Nos. 261–268) which have been referred to the new genus *Glyptoleda*. They were collected from rocks of the Coral or Ingelara Stage at Ingelara Station, near Carnarvon Creek, in the Springsure district. This collection is now in the Australian Museum, but is to be transferred to the University of Queensland. I offer my thanks to Mr. J. H. Reid for the loan of the specimens.

The assistance given by the Shell (Queensland) Development Pty. Ltd., in making available for examination, from their collection in Brisbane, a fine series of specimens of *Glyptoleda* is greatly appreciated. The company generously presented to the Australian Museum the two specimens selected as the holotypes of *G. reidi* and *G. glomerata*.

I am indebted to Dr. Curt Teichert, of the University of Western Australia, for the opportunity of examining and describing the Western Australian material used in the preparation of this paper.

Historical Notes on the Genus Nuculana from Australian Permian Localities.

The first reference to the occurrence of *Nuculana* in the Permian rocks of Australia is Dana's description (1847, p. 157) of an internal cast of a shell from Wollongong, Illawarra district of New South Wales, as *Nucula abrupta*. Two years later, the same author redescribed *N. abrupta* (1849, pp. 698–699) and also described the two additional species, *N. concinna* from Harper's Hill, and *N. glendonensis* from Glendon, both localities in the Hunter Valley of New South Wales. The two former species are referred to the genus *Nuculana*, but it is impossible to come to any definite conclusion regarding *N. glendonensis*. The species was described from an imperfect shell and the figure is meaningless.

A plastotype of *N. concinna*, figured in this paper (Pl. xxii, fig. 3), is an imperfect specimen and shows few definite characters. Although described from the Allandale Stage of the Lower Marine Series at Harper's Hill, it compares very favourably in size and outline with a specimen (F.39313) from the base of the Branxton Stage in the Upper Marine Series. This specimen is figured (Pl. xxii, figs. 4–5) and has been chosen as a plesiotype of the species.

De Koninck (1877, p. 147) described a single shell as *Tellinomya darwini*, from a greyish sandstone in a railway cutting between Maitland and Stony Creek, New South Wales. Etheridge (1888, p. 168) referred this species to the genus *Nuculana*, as he

considered the shell possessed none of the characters of *Tellinomya*. In the same publication, Etheridge described *Nuculana waterhousei*, collected from the Lower Marine Series, Farley Stage, at Wollombi Road cutting, near Farley Railway Station, New South Wales. This species has an unusual fluctuating type of concentric ornamentation which varies considerably on different shells. For various reasons, stated later in this paper, *N. waterhousei* cannot be assigned to the genus *Glyptoleda*.

Johnston (1887, p. 17) described *Tellinomya etheridgei* from the Permian rocks at Porter's Hill, near Hobart, Tasmania. He states that the species "is easily distinguished from *T. darwini* by its more convex valves, and by its more narrowly elongate form". An examination of the figure (1888, pl. xv, fig. 14) proves this species must be placed in the genus *Nuculana*.

Etheridge (1907, p. 8), describing "Carboniferous Fossils from Fossil Head, Treachery Bay, Victoria River Estuary, Northern Australia", named a new species as *Nuculana basedowi*, while a shell with supposedly close affinities to *Nuculana waterhousei* was considered a variety of that species.

The latter has been given specific status and is named *Nuculana undulostriata* to distinguish it from the Eastern Australian species *N. waterhousei* with which it has little in common.

Several specimens from the Upper Marine Series at Burrier, South Coast of New South Wales, were described by Laseron (1910, p. 219) as *Nuculana ovata*. The species recorded by d'Orbigny as *Leda ovata* (1850, p. 236) = *Nucula ovata* Reuss (1846, p. 8) *non* Mantell, is a typical form of the genus *Nucula* and Laseron's name is therefore not a homonym.

Reid (1930, p. 60) recorded *Nuculana* sp. in a list of fossils from the Gympie Formation and from the Lower Bowen Series (1930, p. 63) of Queensland. These specimens are not available for examination and their classification must be deferred.

A single specimen, listed by Raggatt (1936, p. 127) as *Nuculana* sp., from Callytharra Spring, on the Wooramel River, North-West Division, Western Australia, has been examined and cannot be referred to the genus *Nuculana*.

Three poorly preserved specimens of *Nuculana* were collected and listed by Voisey (1939, p. 250) as *N. waterhousei* and *Nuculana* sp. These are in the Australian Museum collection and are from the Linoproductus Horizon of the Macleay Series at "Colraine", Manning River, New South Wales.

The following is a complete list of the Permian species of *Glyptoleda* and *Nuculana* known from Australia, and discussed in this paper:

Glyptoleda reidi sp. nov .. .. Queensland
Glyptoleda glomerata sp. nov. .. .. Queensland
Glyptoleda coleyi sp. nov. .. .. Western Australia
Nuculana abrupta (Dana) .. .. New South Wales
Nuculana ovata Laseron .. .. New South Wales
Nuculana concinna (Dana) .. .. New South Wales
Nuculana basedowi Etheridge .. .. Western Australia
.. .. North Australia
Nuculana etheridgei (Johnston) .. .. Tasmania
.. .. New South Wales
Nuculana darwini (De Koninck) .. .. New South Wales
Nuculana waterhousei Etheridge .. .. New South Wales
Nuculana undulostriata sp. nov. .. .. North Australia

Stratigraphical Notes.

In a recent paper (Raggatt and Fletcher, 1937, pp. 156–159) the Springsure Section of the Queensland Permian is shown to have been revised by several geologists in unpublished reports.

Frank Reeves found the lowest known formation in the area to be the Staircase Sandstone which may underlie the Dilly Stage by a few hundred feet. The Consuelo Sandstone, Ingelara Stage, and the Serecold Sandstone therefore overlie the Dilly Stage, while Reid's Gypseous Stage was thought to be the lower part of the Dilly.

Washington Gray and I. C. H. Croll confirmed Reeve's interpretation of the Springsure Section, but regarded the Gypseous beds as a facies variant of the Dilly. They equated the Aldebaran Sandstone of Reid, which overlies them, with the Serecold Sandstone.

Reid carried out some detailed work on the southern end of the Springsure Dome after the publication of his pioneer work in 1930 and his unpublished results agree to a great extent with the above revisions.

Recent detailed field-work, however, carried out by the Shell (Queensland) Development Pty. Ltd., has made it necessary to alter the succession as it appeared, not only to Reid, but to Washington Gray, Croll and Reeves. It is now known that the Staircase Sandstone overlies the marine beds of the Dilly Stage which now mark the base of the succession in the Springsure area. The Gypseous Stage of Reid is not the equivalent of the Dilly Stage, but is separated from it by the Staircase Sandstone. The correct sequence is now known to be as follows:

Springsure Section—Descending Sequence.

Productus Bed	50–60 feet,	marine
Catherine Sandstone	750 „	non-marine
"Coral" or Ingelara Stage	0–250 „	marine
Aldebaran Sandstone	3,500 „	plants, no marine fossils
"Gypseous" Stage	450 „	
Staircase Sandstone	500 „	marine at base
Dilly Stage	1,800 „	exposed, marine

The above Permian succession has been determined by the Shell (Queensland) Development Pty., Ltd., and it is due to their courtesy that it is published here.

As far as our present knowledge is concerned, the genus *Glyptoleda* is found in Queensland in the "Coral" or Ingelara Stage where it is fairly abundant. It appears as if it is vertically restricted to this horizon. A single specimen of an internal cast of *G. reidi* was collected by Voisey, in 1936, from the Condamine Beds of the Silverwood–Lucky Valley area in Queensland, while an additional specimen was collected by the author during a visit to the area in 1945. In Western Australia the genus has been collected from the Cundlego Series of the North-West Division.

The occurrence of *Glyptoleda*, together with other palaeontological evidence, leads to an interesting revision of the latest work carried out by Voisey in the Silverwood–Lucky Valley area.

Professor H. C. Richards and Dr. W. H. Bryan (1924, pp. 44–107), after a detailed review of the Silverwood–Lucky Valley area, interpreted the Upper Palaeozoic succession, in descending sequence, as follows:

Volcanic Series.
Condamine Beds.
Wallaby Beds.
Eurydesma Beds.

The Eurydesma beds were correlated with the Eurydesma horizon of the Allandale Stage, Lower Marine Series, in the Hunter Valley of New South Wales. The Wallaby Beds were considered the equivalent of the Greta Series, while the Condamine beds and the Volcanic Series were correlated with the Upper Marine Series.

Reid (1930, p. 48) disagreed with this arrangement of the beds, as he considered the available evidence proved the position of the Condamine Beds to be stratigraphically at the base of the series.

The discovery by Voisey (1935, p. 60) of *Monilopora* at the base of the Eurydesma Beds, and its occurrence in the top of the Condamine Beds, made it imperative, according to that author, to place the latter as the basal beds. Additional geological evidence in support of this conclusion is the presence of tuffaceous grits at the top of the Condamine Beds and the base of the Eurydesma Beds, but there is some doubt whether these are lithologically the same.

Voisey and Reid at that time had placed the sequence as follows:

Wallaby Beds.
Volcanic Series.
Eurydesma Beds.
Condamine Beds.

In the Springsure section there is a well defined Cladochonus and Thamnopora zone indicative of the Ingelara Stage. The same conditions exist at Cracow where the coral zone is found high in the sequence. The Eurydesma horizon in the Dilly Stage at Springsure and at Cracow can be correlated with the same horizon in the Allandale Stage of the Hunter Valley of New South Wales. Recent field investigations support this correlation, as it is now known that the Dilly Stage is at the base of the Permian sequence at Springsure. *Thamnopora*, in the Hunter Valley, is found only in the Mulbring Stage of the Upper Marine Series and its equivalent in the South Coast of New South Wales.

It will be seen, therefore, that the above palaeontological evidence from the two Permian successions which have been mapped in the greatest detail, is sufficient to make necessary a revision of the Silverwood-Lucky Valley sequence as then outlined by Reid and Voisey. The Condamine Beds containing the Thamnopora and Cladochonus zone must be placed well above the Eurydesma Beds. Additional evidence is the presence of *Glyptoleda reidi* in the Condamine Beds. This genus is restricted in Queensland to the Ingelara Stage, where it is found associated with the two corals.

Thamnopora wilkinsoni, however, is known only from the Upper Marine Series in the Hunter Valley, where it is found in abundance. Hill (1940, p. 67) records it from "the Coral Stage of the Bowen marine of the Springsure Basin, Queensland, and in the Condamine Fault Block, near Silverwood, Queensland".

Cladochonus nicholsoni has very little value as a "marker" fossil, but in this case, where it occurs in abundance in a well defined zone, it must have some correlative significance. Specimens from the Condamine Fault Block and from the "Coral" or Ingelara Stage of Springsure have been identified by Dr. D. Hill (1942, p. 69) as being identical, and very close to specimens from Balmaningarra, Mount Marmion, Western Australia.

Voisey has from time to time published the results of his investigations in Permian areas on the north coast of New South Wales.

At Drake and Boorook, he (1936, pp. 159–162) found *Thamnopora wilkinsoni* associated with *Cladochonus nicholsoni* in a mudstone near the base of the Upper Division of the Drake Series in the Crooked Creek area and in abundance near the top of the Series at Sawpit Gully in Zone D.

During a recent visit to Boorook and Silverwood, both Voisey and the author came to the conclusion that Zone D at Sawpit Gully and the Condamine Bed at Silverwood bear a strong resemblance to one another and must be correlated. The evidence in favour of this course is the very close similarity of the two corals, their mode of preservation, and the close lithological resemblance of the matrix in the two localities.

The Zone D at Sawpit Gully is high in the Permian sequence and agrees well with the position of *Thamnopora* and *Cladochonus* in the well-known Permian successions.

Eurydesma has not been collected at Drake or Boorook, but it has been recorded by Andrews to the north in the Rivertree district from strata of which the stratigraphical position has not yet been determined.

Voisey has traced the Permian beds, the equivalents of the Lower Marine Series, from the Macleay River to the Manning River and refers to them as the Macleay Series. These beds are not of great thickness and are easily traced because of the outstanding *Eurydesma* limestone horizon.

At the base of the sequence at Dondingalong, near Kempsey, in Zone A, *Ptychomphalina* is recorded in abundance, while in the Hunter Valley this small gastropod is plentiful both in the Upper Marine Series and low in the Lower Marine Series.

The known range of *Linoproductus springsurensis*, in the type locality at Springsure, is the upper section of the Dilly Stage, from the main Eurydesma horizon to the top of the stage. The Dilly Stage of Springsure can be considered the age-equivalent of the Allandale Stage of the Hunter Valley and the Eurydesma bed at Silverwood. At Dondingalong, *Linoproductus* is found in a definite zone below the main Eurydesma horizon, while at Kimbriki on the Manning River it is high in the sequence of that area and is found in abundance in beds which could be the equivalent of the Farley Stage of the Hunter Valley.

It is a remarkable fact that neither *Cladochonus* nor *Linoproductus* has been found in the Permian beds of the Hunter Valley. There appears to be no valid explanation to account for their absence and it is possible they may yet be collected.

It will be seen from the above review of palaeontological evidence that the Thamnopora wilkinsoni and Cladochonus nicholsoni zone is not found below the Eurydesma horizon. Voisey (1936, p. 196) has recorded its occurrence in the Eurydesma horizon, but the main zone is much higher in the sequence. This evidence precludes any possibility of the Condamine Bed of the Silverwood-Lucky Valley area being placed below the Eurydesma Bed. Furthermore, the occurrence of *Glyptoleda reidi* in the Condamine Bed strengthens its correlation with the "Coral" or Ingelara Stage of Springsure. The Eurydesma Bed must be placed at the base of the Permian sequence at Silverwood.

Sussmilch (1935, p. 108) is of the opinion that Reid is correct in his interpretation of the Silverwood-Lucky Valley sequence, but considers the strata of the Condamine Block, including the volcanic rocks, to be probably of Upper Carboniferous age. Voisey (1939, pp. 389–390) revised his previous conclusions regarding the Silverwood area after he had completed detailed field-work at Drake and Boorook. He considers the Condamine and Wallaby Beds are the equivalents, at Silverwood, of part of the Upper Division of the Drake Series.

The Volcanic Series is correlated with the Lower Division of the Drake Series, while there is some doubt regarding the position of the Eurydesma Beds.

I have already stressed that the rather general palaeontological evidence outlined in this paper strongly suggests that the Condamine Beds must be placed at the top of the Silverwood-Lucky Valley Permian succession, while the Eurydesma Beds, with a well-defined horizon crowded with *Eurydesma cordata*, must be considered the basal beds in that area.

Richards and Bryan were of the opinion that the lower freshwater beds of the Wallaby Stage showed a marked similarity with the Greta horizon of the Hunter Valley, and in my opinion the evidence strongly supports this. It is significant that in the lower portion of the Wallaby Stage, *Gangamopteris* predominates over *Glossopteris* as is the case in the Greta Beds. In the Upper Coal Measures the reverse is the case. Furthermore, the occurrence of abundant *Terrakea* and *Strophalosia* in the marine beds of the upper portion of the Wallaby Stage strongly suggests a correlation with the Branxton Stage of the Hunter Valley and its South Coast equivalent.

The Volcanic Beds are a problem as the fauna is typical of either the Lower or Upper Marine Series. *Aviculopecten mitchelli* and *Deltopecten farleyensis* cannot be accepted as indicating a lower marine age for these beds as both species are now known to be not uncommon in the Upper Marine Series. Specimens of the latter species were collected by Mr. E. C. Andrews from near the Golden Age Mine at Boorook, in beds which I presume would belong to the upper division of the Drake Series. This locality is less than forty miles from Silverwood. On the other hand, there is a decided Upper Marine aspect in the list of fossils collected from the Volcanic Beds. The abundance of *Martiniopsis*, together with the associated species, and particularly if *Terrakea brachythaera* is plentiful, suggests an Upper Marine age similar to the upper portion of the Wallaby Beds and the Branxton Stage of the more southern Permian sequence. It is certain that extensive collecting from the Fault Block Series would throw a good deal of light on the arrangement of the beds.

A microscopical examination of the volcanic rocks at Silverwood and comparisons made with those at Drake and Boorook would also lead to some important conclusions in correlation.

The obvious correlation of the Volcanic Beds at Silverwood would appear to be with the volcanics of the Lower Division of the Drake Series. In this series, however, there are no known fossiliferous horizons, and furthermore the palaeontological evidence tends towards them being higher in the Permian sequence in beds the age equivalent of the Upper Marine Series of the Hunter Valley.

I am of the opinion that the descending sequence of the Fault Block Series should be considered as follows:

Condamine Beds.
Volcanic Series.
Wallaby Beds.
Eurydesma Beds.

A summary of the Upper Palaeozoic stratigraphy in the North-West Basin of Western Australia has been published by Raggatt (1937, p. 167) and by Teichert (1941, p. 381). In the Cundlego Series of the Minilya River the genus *Glyptoleda* is represented by *G. coleyi*. This species has only a few points of difference from the Queensland shells and, if my assumption that the genus *Glyptoleda* with its highly specialized ornamentation is restricted in its vertical range is correct, then it is interesting and significant to find the genus occurring in both these two widely separated Permian horizons.

Description of Species.

Class LAMELLIBRANCHIA Blainville.

Family Nuculanidae Stoliczka.

Genus Glyptoleda gen. nov.

Genotype: *Glyptoleda reidi* sp. nov.

Generic characters.—Shell equivalve, elongate, narrowing posteriorly, acuminated; closed all round, comparatively robust with thickened test. Umbones small, depressed, contiguous and slightly recurved posteriorly. Lunule and escutcheon well developed, elongated. Posterior umbonal ridge concave, bent upwards at the extremity.

Hinge plate furnished with strong teeth which abruptly diminish in size nearing the umbo. There are about ten wide teeth on the short convex anterior portion while on the concave posterior portion twelve–fourteen narrower teeth are present. A ligamental pit situated below the umbones divides the teeth into two sets.

Anterior and posterior adductor muscle scars well marked, deeply excavate. Pallial line entire.

Surface ornamented with diverging V-shaped ribs the sides of which in many cases have been developed into a wavy, zig-zag design.

The shells range from 30 mm. to 50 mm. in length and from 18 mm. to 33 mm. in height.

Observations.—The shells included under the genus *Glyptoleda* have many characters which link them with the genus *Nuculana*. The general shape is essentially the same, as are also the hinge structures and musculature markings. They differ, however, in being much larger in size, having a solid, thick test and possessing a well-marked V-shaped ornamentation. These characters denote a definite specialized group of *Nuculana*-like shells which are quite distinct from the normal genus with its, for the most part, surface ornamentation of fine, regular, concentric ribs.

The ornamentation on shells of *Glyptoleda* differs in pattern on valves of the one shell, but, in the series examined, remains constant in the species.

The presence of a somewhat similar type of ornamentation to that found in *Glyptoleda* is characteristic of several species in closely allied genera. The surface ornamentation on *Nuculana waterhousei* Etheridge, is composed of numerous fine wavy striae which form an irregular V-shaped pattern. In this species the ornamentation varies a good deal on individual specimens. Specimens of *Nucula* (*Acila*) *bivirgata*

Sowerby possess an ornamentation which may be compared somewhat with *Glyptoleda*. The form of the ornamentation however is not constant and varies markedly in different shells.

The genus *Nuculana* is cosmopolitan in its distribution and has a geological range from the Silurian to present day. *Glyptoleda*, on the other hand, as far as present knowledge is concerned, is restricted in its vertical range and is known only from the "Coral" or Ingelara Stage, the Condamine Beds (Queensland), and the Cundlego Series of the Permian sequence in Western Australia.

Glyptoleda reidi sp. nov.

(Plate xix, figures 1–5.)

Holotype: F.41404, Australian Museum Collection.

Paratype: No. 265, University of Queensland Collection.

Specific Characters.—Shell transversely elongated, robust, more than twice as long as high. Umbones small and depressed, recurved posteriorly and contiguous, situated well in the anterior half of the shell.

Anterior end inflated, less than half the length of the shell, margin oval. Inferior margin gently curved, posterior end long and tapering, with an umbonal ridge extending from the umbo to the posterior extremity. Posterior extremity pointed. Posterior umbonal ridge broadly concave, cutting off a flattened dorsal area or rostrum. Hinge-line depressed anteriorly, posteriorly straight, slightly raised above the escutcheon, and sloping gradually from the mid-line of the escutcheon to the pointed posterior extremity.

In front of the umbones is an elongate, narrow, depressed lunule. Posterior to the umbones is a broad escutcheon bordered by the two umbonal ridges which extend from the apex of the umbones and, sloping downwards, join at the pointed extremity of the shell. The escutcheon is again divided by two ridges which originate from near the base of the umbones and pass obliquely backwards to meet at a point on the hinge-line more than half-way to the posterior extremity of the escutcheon. The inner enclosed area is diamond-shaped and ornamented with fine longitudinal striae. The outer portion of the escutcheon is convex, ornamented with wavy striae which extend over the umbonal ridge from the surface of the valve and pass obliquely forward.

The surface ornamentation consists of about 25–30 fine ribs which follow a complicated pattern. The anterior portion of the valve is sculptured with wavy, confused ribs, more or less concentric until they reach a position below the apex of the umbo when they pass upwards to join the umbonal ridge. On the posterior part of the valve the zig-zag nature of the ribs is more pronounced with small series of Vs developed at fairly regular intervals.

An internal cast shows well-marked muscle scars and a well-defined entire pallial line. Anterior adductor muscle scar situated slightly above the extreme anterior extremity, slightly excavate posteriorly. Posterior adductor muscle scar situated on the umbonal ridge near its extremity, excavate anteriorly.

A small ligamental pit immediately below the umbo divides the hinge-plate into anterior and posterior portions. The anterior portion is slightly convex with about eight–ten moderately curved strong teeth. The posterior portion is concave and bears 12–16 similarly shaped teeth. The teeth abruptly diminish in size near the base of the umbo.

The dimensions of several shells are as follows:

	Holotype. (F.41404.)	Paratype. No. 265.	(Int. Cast). F.36431.
Length	41 mm.[1]	47 mm.	37 mm.
Height	21 mm.	22 mm.	16 mm.
Thickness	12 mm.	16 mm.	—
Apical Angle	138°	140°	140°

Observations.—This species is represented by a series of well preserved specimens and an internal cast of a left valve. It differs markedly from *G. glomerata*, with which it is associated in the Ingelara Stage, by being more elongated and possessing an apical

[1] Posterior portion incomplete: actual length would be at least 46 mm.

angle of 140° whereas *G. glomerata* has an angle of 124°. It is easily distinguished from *G. coleyi* as that species has the inferior margin separated into a convex anterior portion and a straight posterior portion. The ornamentation of the valve also consists of ribs which are finer and more widely separated than in *G. reidi*.

Localities and Geological Horizons.—Queensland: Ingelara, Carnarvon Creek, near Springsure, Queensland. Paratype locality. (Coral or Ingelara Stage.) Southern plunge of the Serecold Structure, 2·19 miles N. 265°E. of Ingelara Station[2]—Springsure district, Queensland. (Holotype locality.) (Coral or Ingelara Stage.) Silverwood, Queensland. (Condamine Beds.) F.36431.

Glyptoleda glomerata sp. nov.

(Plate xx, figures 1–3.)

Holotype: F.41405, Australian Museum Collection.

Description.—Shell equivalve, inequilateral, transversely ovate, inflated, less than twice as long as high. Anterior margin elliptically oval. Inferior margin broadly convex, posterior margin bluntly pointed. Antero-dorsal margin convex, postero-dorsal margin concave. A well-marked, slightly concave umbonal ridge extends from the umbo to the posterior extremity. Between the umbonal ridge and the cardinal line a flattened rostrum is developed.

Umbones prominent, contiguous, recurved posteriorly, situated in the anterior half of the shell, but almost central. Umbonal region swollen but tapering rapidly to all margins. Anterior of the umbones is a well-defined depressed lunule, slightly raised in the mid-line to form the hinge-line; posterior to them is an elongated broad escutcheon marked off by the posterior umbonal ridge. The escutcheon itself is divided into two portions by a ridge originating from the lower part of each umbo and extending obliquely inwards and backwards to meet in the middle line. Both portions of the escutcheon are flatly concave. The inner surface is ornamented with fine longitudinal lines, the outer surface with oblique wavy striae. Test comparatively thick.

Internal characters not exhibited.

The surface ornamentation is different on the two valves of the one shell and consists of large V-shaped ribs the sides of which are wavy and developed into small Vs at regular intervals. The ornamentation of the right valve is divided into anterior and posterior portions by a well-defined mid-line formed by the bases of the large Vs. On the anterior half the ribs pass obliquely, with narrow interspaces, from the antero-dorsal margin to the mid-line, where they abruptly change direction and pass upwards to the umbonal ridge, thus forming a large V, the bases of which are approximately in the mid-line of the valve. The ribs arising from the lower part of the antero-dorsal margin and the anterior margin pass obliquely to the inferior margin and do not extend to the mid-line. The ribs are wavy and occasionally series of small Vs are developed at regular intervals on the anterior half. Narrow zones are thus formed radiating from the umbo to the inferior margin.

The ribs on the posterior half of the large Vs consist of wavy almost straight striae, with wider interspaces, which pass upwards to the umbonal ridge and continue on to the outer portion of the escutcheon. Small Vs are not developed on the posterior striae. On the left valve the ornamentation is similar, except that the base of the large V, formed in the mid-line by the longer striae, is wide and crenulated.

The dimensions of the holotype and a large specimen are as follows:

	Holotype. (F.41405.)	(W.1738, No. 3.)
Length	30 mm.	55 mm.
Height	19 mm.	30 mm.
Thickness	12 mm.	21 mm.
Apical angle	124°	122°

Observations.—This species is fairly common in the Ingelara beds and varies a good deal in size. A specimen in the Shell Company's collection in Brisbane (W.1738, No. 3)

[2] Co-ordinates of Ingelara Station. Lat. 24° 56′ 50″, Long. 148° 18′ 16″.

attains considerable size as shown in the list of dimensions. The holotype is the smallest shell in the series but is the most perfectly preserved. The rapidly sloping umbonal ridge with an apical angle of 124° easily distinguishes this species from *G. reidi* and *G. coleyi*. The shell is more truncate and the umbones are situated almost centrally.

The species is represented by a series of ten well-preserved shells found in the Ingelara Stage associated with *G. reidi*.

Localities and Geological Horizon.—Queensland: Ingelara, Carnarvon Creek, near Springsure (Ingelara Stage). Southern plunge of the Serecold Structure, 3·44 miles N. 192° E. of Trig 37[3] (Ingelara Stage). Western flank of the Serecold Structure of Bela Creek, 1·06 miles N. 330° E. of Mt. Serecold[4] (Ingelara Stage). Southern plunge of the Serecold Structure, 2·19 miles N. 265° E. of Ingelara Station[5] (Holotype locality) (Ingelara Stage).

Glyptoleda coleyi sp. nov.

(Plate xix, figs. 7–9.)

Holotype: No. J35 (2) University of Western Australia Collection.

Paratype: No. T168, University of Western Australia Collection.

Description.—Shell transversely elongated, equivalve, inequilateral, more than twice as long as high. Anterior end inflated, produced inferiorly, bluntly rounded. Posterior end long, slightly compressed, tapering to a pointed extremity. A distinct umbonal ridge extends from the apex of the umbo to the posterior extremity cutting off a flattened dorsal area or rostrum. Inferior margin gently convex in the anterior two-thirds of the shell, almost straight posteriorly.

A shallow sinus extends slightly backwards from the umbo to the inferior margin and marks the junction between the more or less swollen anterior and the flattened posterior end of the shell.

Umbones small and depressed, recurved posteriorly. Lunule distinct, narrow and elongate. Escutcheon flattened, lanceolate, and divided into two parts by a ridge arising from the base of the umbo and passing backwards and inwards to meet in the mid-line. The ridges appear to have been ornamented with about sixteen evenly-spaced nodules.

The hinge-plate is divided into anterior and posterior portions, separated by a small and deep ligamental pit. The anterior portion is convex, situated higher on the shell than the posterior portion, and bears approximately 10 teeth which diminish in size rapidly towards the umbo. The posterior portion is longer, concave, bearing about 16 teeth.

The surface of the right valve is ornamented by extremely fine wavy ribs with wide, smooth interspaces. These follow the characteristic pattern of the genus in possessing the large V, but smaller Vs are not developed. The ribs on the anterior end of the valve extend obliquely from the antero-dorsal margin to a central line extending almost vertically from the umbo to the inferior margin, when they pass abruptly to the cardinal margin, forming the wide V. The Vs are small on the umbonal flank but increase in size towards the inferior margin. Following the course of the inferior margin is a narrow area of heavy concentric growth lines. This narrow marginal area is possibly due to weathering.

Internal muscular markings are not exhibited.

The dimensions of the holotype are as follows:

Length	43 mm.
Height	21 mm.
Thickness	14 mm.
Apical Angle	132°

Observations.—This Western Australian species is represented by a single well-preserved right valve, and two badly weathered imperfect specimens. An immature shell (J44) is also recorded as this species. It is a distinctive form, characterized by

[3] Co-ordinates of Trig. 37. Lat. 24° 56′ 50″, Long. 148° 18′ 16″.

[4] Co-ordinates of Mt. Serecold. Lat. 24° 50′ 21″, Long. 148° 16′ 53″.

[5] Co-ordinates of Ingelara Station. Lat. 25° 0″, Long. 148° 20′ 21″.

the anterior end of the shell being inflated, while the posterior end is somewhat flattened or compressed.

The inferior margin is not regularly curved, as in other species of the genus, but is anteriorly convex and posteriorly almost straight. The ornamentation differs from other species of this genus in the ribbing being finer and the larger sides of the V not developed into any pattern by zig-zag structure.

Localities and Geological Horizon.—Western Australia: Barrabiddy Creek, 19 chains upstream from the fence between Weir and Barrabiddy Paddocks. (Holotype locality.) (In shales of the Cundlego Series.) About 10 chains from the southern bank of Whitfield's Creek, 110 chains from its junction with the Minilya River. (Paratype locality.) (Cundlego Series.) River Flat of Minilya River, 36 chains N.W. of mouth of Whitfield's Creek. (Cundlego Series.) J44.

Genus Nuculana H. F. Link, 1807.

Beschreib. der Naturalien-Samml. der Universitat zu Rostock, Vol. iii, p. 155.

Observations.—The genus *Nucula* was established by Lamarck (1799, p. 87) to include a group of shells of which *Arca nucleus* Linn. was the type species. Included in this group were shells with a prolonged posterior end, and Link (1807, p. 155) proposed the genus *Nuculana* to include this form, with *Arca rostrata* Chem. as the type species.

However, Schumacher (1817, pp. 55 and 173) instituted the genus *Leda* for the same type of shell, even selecting *Arca rostrata* Chem. as the type species of his genus. On page 172, Schumacher states that: "Lamarck established a genus under the name *Nucule* (*Nucula*) and takes as the type of his genus *Nucule nacree* (*Nucula margaritacea*) or *Arca nucleus* Linn. In examining this shell I have found that the hinge has much more in common with that of *Pectunculus* and that is the reason I have changed the name of his genus into that which I have given it."

From this statement one can only conclude that Schumacher established the genus *Leda* for shells of the *Nucula* type, although he figured *Arca rostrata* as the type species of his genus. He actually has instituted *Leda* as a substitute name for *Nucula* of Lamarck, as he considered the shells were more referable to *Pectunculus* and therefore changed the name of the genus to *Leda*.

It will be clearly seen from the above evidence that the name *Leda* cannot be used for shells after the type *Arca rostrata* for several reasons. *Nuculana* of Link has clear priority over the genus *Leda* as it was established ten years earlier and, furthermore, it seems very apparent that *Leda* of Schumacher must be associated with the genus *Nucula* of Lamarck, either as a new name or as a synonym of that genus.

Waagen (1887, p. 248) states the name *Nuculana* must stand in preference to *Leda* of Schumacher for two reasons: because *Nuculana* has long priority, and because *Leda* had already been pre-occupied for a genus of Arachnids. Waagen's first reason is perfectly correct, but his second reason is not a valid one as the Arachnid genus *Leda* was not proposed by Koch and Berendt until 1845 (1845, p. 93), so that according to the law of priority it would have had no standing.

In most palaeozoic species of *Nuculana* an internal ridge originates at the apex of the umbo and extends downwards towards the inferior margin. This ridge on internal casts is shown as a distinct groove in which two small but well-defined muscle scars are usually situated high on the valve. Various authors, e.g. Thomas (1928, p. 217), Hind (1897, p. 194) and Girty (1915, p. 123), have referred to this feature in a number of British and American species, but its function still remains largely in doubt.

The muscle scars are considered, and logically so, to represent the points of attachment of the mantle. In some Australian species, however, the groove and muscle scars are absent, and in *N. waterhousei*, a form in which the groove is well developed, no muscle scars are present. Furthermore, in recent shells of *Nuculana* there is no trace of an internal ridge or muscle scars on the umbonal flank.

The two muscle scars are well defined in *N. abrupta* and *N. darwini*, consisting in both species of a large dorsal scar and a smaller subsidiary scar immediately below it. The groove in these species is, however, short and shallow.

Nuculana abrupta (Dana).

(Plate xxi, figs. 4–6.)

1847. *Nucula abrupta* Dana, Amer. Journ. Arts and Sc. (2), iv, p. 157.

1849. *Nucula abrupta* Dana, U.S. Explor. Exped. (Wilkes') Geology, x, p. 698, pl. 7, figs. 3, 3a (Atlas).

Holotype: Imperfect specimen described by Dana (1847, p. 157), in the collection of the Smithsonian Institution, United States National Museum.

Plesiotype: F.24240, Australian Museum Collection.

J. D. Dana, in his preliminary report in 1847, gives the following original description of this species:

"Thick, elongate, transverse, rather abruptly narrowing behind the summit, and diminishing posteriorly; posterior dorsal margin much concave; anterior margin rounded; cast strongly carinate from the beak to the posterior angle, and having a wide and flat cardinal area; pallial impression distinct, somewhat excavate, smooth; anterior muscular impression somewhat excavate, smooth; posterior strongly excavate in upper part (in the cast it lies around the posterior carina, and the upper extremity forms an abrupt angle on the outline of the carina); surface of cast smooth, some faint radiations hardly distinguishable. Length 1⅓ inches; height $\frac{60}{100}$L; thickness $\frac{40}{100}$ or, $\frac{45}{100}$L; apical angle about 135°; height in the line of the upper part of the posterior muscle, about half greatest height."

Observations.—Dana in his more extended account (1849) of the geology of the Wilkes' Expedition redescribed *Leda abrupta*, but did not add a great deal of information. In his observations he states "the specimen is an internal cast, and shows finely the numerous teeth of the hinge. The pallial impression is about 1½ lines from the inferior margin. There are a few faint rays on the surface of the cast, visible in certain lights."

After an examination of a plastotype of Dana's species, figured in this paper, I have no hesitation in referring two specimens in the Australian Museum Collection to his species. Dana's specimen was collected from Wollongong Point, Illawarra, while the two additional shells came from Black Head, near Gerringong, some twenty miles to the south of Wollongong, and from the same horizon, the Crinoidal Stage of the Upper Marine Series. The Crinoidal Stage is the highest stage in the Permian on the South Coast of New South Wales and in all probability is the horizontal equivalent of the Mulbring Stage in the Permian Succession of the Hunter Valley.

A well-preserved specimen of both valves, partly testiferous (F.24240), exhibits the following additional characters to those described by Dana.

A well-defined, cordate escutcheon extends from the umbones to a point opposite the centre of the posterior adductor muscle scars. A wide and distinct lunule is present. The muscle scars are essentially as described by Dana and the pallial line is entire. The anterior adductor scar is oval, of medium size, not deeply excavate, and extends to the dorsal umbonal ridge which it slightly overlaps. The posterior adductor scar is tear-shaped, rather strongly excavate antero-dorsally, situated on and oriented with the posterior umbonal ridge. An internal ridge or furrow extends from the median apex of the umbo towards the inferior margin. In casts it appears as a groove or sinus. A small rounded distinct muscle scar, with a small subsidiary scar immediately below it, is found in the centre of this groove, just below the apex of the umbo. The function of the muscles which these scars represent is doubtful, but they were possibly connected with the mantle.

The teeth are divided into a slightly convex anterior and a concave posterior series, but are not exhibited sufficiently to determine their number.

The ornamentation of the valves consists of close and regularly arranged concentric ribs.

The present species, *N. abrupta*, bears no distinct similarity to other Australian species of the genus because of its large size, and rapidly sloping concave umbonal ridge. The dimensions of two specimens are as follows:

	Plesiotype. F.24240.	Holotype Incomplete.
Length	33 mm.	30 mm.
Height	20 mm.	19 mm.
Thickness	14 mm.	—
Apical angle	130°	125°

Localities and Geological Horizon.—New South Wales: Black Head, near Gerringong (Plesiotype, F.24240); Wollongong (Holotype) (Crinoidal Stage, Upper Marine Series, Permian).

Nuculana ovata Laseron.

(Plate xx, fig. 4; Plate xxi, fig. 3.)

1910. *Nuculana ovata* Laseron, Journ. and Proc. Roy. Soc. N.S.W., xliv, p. 219, pl. xv, figs. 5–7.

Holotype: F.20176, Australian Museum Collection.

Laseron, in describing this species, confused the anterior and posterior portions of the shell and attention must be paid to this fact when reading his diagnosis.

Nuculana ovata differs from other shells of this genus in being almost equilateral. The umbones are almost centrally situated, being placed only slightly anterior to the mid-line. The posterior portion of the shell is therefore not elongated and tapered to such a marked degree as in other species of the genus. A well-marked posterior umbonal ridge, somewhat rounded and concave, extends from the umbo to the posterior extremity, and between it and the raised cardinal line the valve is strongly concave. This enclosed area forming the escutcheon is divided into two portions by a ridge originating at the base of the umbo and extending backwards and inwards to meet at the cardinal line about half-way to the posterior extremity. The inner portion of the escutcheon is flattened and ornamented by longitudinal striae. The outer concave portion is ornamented by a continuation of the valve ribbing which, on crossing the umbonal ridge, passes abruptly forward.

The ornamentation on the valve surface is the characteristic type of the genus, consisting of about 35 fine concentric ribs, becoming more prominent towards the ventral margin and separated by fairly wide, deep interspaces. The pallial line is not shown. The test is comparatively thick for such a small shell. The hinge plate consists of anterior and posterior portions separated by a well-defined ligamental pit immediately below the umbo. Posteriorly there are approximately fourteen teeth, diminishing in size at both ends of the series. Anteriorly the teeth are not exhibited.

The dimensions of two specimens are as follows:

	Holotype.	F.41406.
Length	18 mm.	13 mm.
Height	12 mm.	9 mm.
Thickness	9 mm.	6 mm.
Apical angle	120°	110°

Laseron secured several examples of this species from the Wandrawandian Series at Burrier, south coast of New South Wales. It is a small form, characterized by comparatively heavy concentric ornamentation, by the almost central position of the umbones, and by the upraised posterior cardinal line. It has some similarity with *N. abrupta*, but, as pointed out by Laseron, is separated from that species by "the more central situation of the umbones, and the much shorter nature of the anterior extremity and also in the relative proportions of the length to the height".

A small complete and beautifully preserved specimen of both valves and an internal cast from the lower part of the Branxton Stage, near Cessnock, have been identified as *N. ovata*. There is a tendency for the ribbing to become slightly wavy towards the posterior end of the shell in this species.

Localities and Geological Horizon.—New South Wales: Burrier, near Nowra (Holotype locality) (Wandrawandian Series, Upper Marine Series). Abermain No. 3 shaft, near Cessnock (Lower Branxton Stage, Upper Marine Series).

Nuculana concinna (Dana).

(Plate xxii, figs. 3–5.)

1847. *Nucula* .....? Dana, Amer. Journ. Arts and Sci. (2), iv, p. 157.

1849. *Nucula concinna* Dana, U.S. Explor. Exped. (Wilkes') Geology, x, p. 699, pl. 7, fig. 4. (Atlas.)

Holotype: Specimen figured by Dana (1849, pl. 7, fig. 4), in the collection of the Smithsonian Institution, United States National Museum.

The original description of this species published by Dana in 1849 is as follows:

"We thus name a small delicate species of which we have but an imperfect specimen. It has a smooth exterior with occasional lines of growth, and the valves thin. The form is oblong ovate, subacuminate and thinning much behind; length nearly twice the height; surface not at all carinated posteriorly; apical angle nearly 150°."

A plaster replica of Dana's single imperfect specimen (No. L.671, in the Australian Museum Collection) shows it to be a decorticated shell of both valves, with the lower posterior portion missing. Dana records an apical angle of 150°, an extreme reading due to the poor preservation of the shell, and in my opinion the apical angle is nearer 135°.

There are two specimens in the Australian Museum Collection, including one exceptionally well-preserved shell of both valves, from the Abermain No. 3 Shaft, near Cessnock, New South Wales, which, after some hesitation, I have assigned to Dana's species *Nuculana concinna*. They agree well in general appearance with the poorly preserved holotype collected by Dana at Harper's Hill, low in the Allandale Stage of the Lower Marine Series. On the other hand, the two additional specimens were collected from strata about 200 feet above the base of the Branxton Stage of the Upper Marine Series.

Additional characters of this species are as follows:

Shell equivalve, very inequilateral, elongated, anterior end short and rounded; posterior portion long and tapering posteriorly to an almost pointed extremity.

Anterior margin broadly rounded, joining evenly with the inferior margin which for the anterior two-thirds is rounded, the posterior one-third straight. Antero-dorsal slope convex; posterior umbonal ridge slightly concave, almost straight, extending from the apex of the umbo to near the ventral margin, where it forms a bluntly-pointed posterior margin or extremity. The umbonal ridge cuts off a narrow, elongated escutcheon which is well defined and lanceolate. A well-marked ridge originates at the base of the umbo and, passing backwards and inwards, meets the cardinal line in about the centre of the escutcheon. This ridge, ornamented with twelve distinct regularly-spaced nodules, divides the escutcheon into an inner and an outer portion. The inner area is flattened and ornamented with fine longitudinal striae. The outer portion is concave, ornamented with ribs which are a continuation of the valve ornamentation, but are finer and bend sharply forward as they cross the umbonal ridge.

The hinge-plate is divided into anterior and posterior portions by a well-defined ligamental pit at the base of the umbones. The anterior portion is convex with about eight–ten teeth, while the much longer posterior and slightly concave portion has about fourteen teeth. Anterior adductor muscle scar elongate, oval, not excavate. Posterior adductor muscle scar not exhibited. Umbonal sinus or furrow not present.

The surface ornamentation consists of fairly coarse, concentric, regularly-arranged ribs which increase in strength towards the ventral margin. The ribs are 35 in number,

crowded on the umbonal region, but on the flanks and towards the ventral margin are separated by comparatively wide interspaces.

The dimensions of a well-preserved specimen (F.39313), chosen as a plesiotype, are herewith compared with measurements of the plastotype:

	Plesiotype (F.39313).	Plastotype (L.671).
Length	23 mm.	25 mm.
Height	13 mm.	15 mm.
Thickness	10 mm.	10 mm.
Apical angle	130°	135°

Observations.—This species has ornamentation somewhat similar to *N. ovata* Laseron, but is easily distinguished from that species by the more elongated nature of the shell. From *N. darwini*, a species with which it is found in the Branxton Stage, it is readily distinguished by the numerous and fine ribbing of the ornamentation of the latter species. Both species possess nodules on the dividing ridge of the escutcheon, but in *N. concinna* they are more distinct than in *N. darwini*, where they appear to be more in the form of whitish dots than nodules.

Localities and Geological Horizon.—New South Wales: Abermain No. 3 Shaft, near Cessnock (200 feet above base of the Branxton Stage, Upper Marine Series). Harper's Hill (Holotype locality.) (Lower Allandale Stage, Lower Marine Series.)

Nuculana darwini (De Koninck).

(Plate xxi, figs. 1–2, plate xxii, figs. 1–2.)

1877. *Tellinomya darwini* De Koninck, Foss. Pal. Nouv. Galles du sud, Mem. Soc. Roy. Sci. Liége, Ser. 2, Vol. ii, p. 147, pl. xvi, fig. 9.

Holotype: Destroyed in the Garden Palace Fire, 1882 (Sydney International Exhibition, 1879).

Neotype: F.41409, Australian Museum Collection.

Plesiotype: F.41412, Australian Museum Collection.

This species was described by De Koninck from a single shell found in a greyish sandstone, in a railway cutting between Maitland and Stony Creek, New South Wales (Branxton Stage of the Upper Marine Series). The holotype of the species was destroyed in the Garden Palace Fire of 1882 and our knowledge of the species is derived from the description and figure given by De Koninck, and a single specimen figured by Johnston (1888, pl. xv, fig. 12) as occurring in the marine mudstones at Porter's Hill, Hobart, Tasmania. In the text, however, there is no mention of this species from Porter's Hill, and on page 115, in a list showing the distribution of species in Australia, the author records *N. darwini* as occurring only in New South Wales.

I have included in this species a series of well-preserved shells which are found in abundance in the matrix from Abermain No. 3 Shaft, and the Caledonian Shaft, near Cessnock (base of the Branxton Stage, Upper Marine Series). The specimens are slightly smaller in size, but otherwise agree so well in all other characters that I have no hesitation in assigning them to De Koninck's *N. darwini*. It is an interesting species and as internal casts have been preserved showing the internal structure the following additional characters are noted.

Shell small, equivalve, inequilateral, elongated posteriorly; moderately convex, tapering rapidly to form an attenuated and pointed posterior extremity. Anterior margin oval, produced inferiorly and merging with the broadly convex ventral margin. Antero-dorsal margin almost straight; posterior umbonal slope concave, extending to posterior extremity. Apical angle 125°.

Umbones situated anteriorly, recurved posteriorly, depressed. An indistinct, rounded ridge originates at the apex of the umbo and extends backwards to the bluntly-pointed posterior extremity.

Above this ridge the valve is concave to the cardinal margin and forms a well-defined escutcheon. The outer portion is ornamented with closely-packed fine longitudinal ribs,

the continuation of the valve ribbing, bent sharply backwards as they cross the umbonal ridge to run parallel with the cardinal line. A ridge passing from the apex of the umbo, backwards and inwards to the cardinal margin, encloses an inner portion of the escutcheon. This is ornamented with fine striae. The ridge possesses regularly-arranged indefinite nodules. On internal casts a shallow groove extends from the umbo towards the inferior margin, on the flank of the umbonal slope; the groove is short and does not quite reach the middle of the valve. Two distinct muscle scars are present in the furrow, an oval dorsal one and a smaller elongate lower one. The scars are deeply excavate and ornamented with several lines, denoting stages of growth. On the interior of the test the two deep cavities for the reception of these muscles are clearly visible, but the ridge itself is not well defined.

The adductor muscle scars are very distinct. The anterior scar is rounded, deeply excavate posteriorly, and possesses a very fine cancellate sculpture, the concentric lines being the stronger; it is situated high on the valve near the end of the cardinal line, and is excavate posteriorly. A fine ridge passes back parallel to the cardinal line, joining the adductor scar with a small pedal scar placed at a point half-way to the umbo and alongside the cardinal line. The posterior adductor scar is situated more on the umbonal ridge than on the flank of the valve, and is more than two-thirds of the way from the umbo. The scar is deeply excavate anteriorly, ornamented with four distinct lines; a notch is developed in the anterior margin of the scar. The pallial line is distinct and does not possess a sinus.

The surface of the valve is ornamented with at least seventy-five closely-packed fine concentric ribs, fairly regularly arranged. Where the valve narrows posteriorly, the ribs at times merge together and they become slightly wavy. The surface of the valve is covered with fine longitudinal ridges of a very fine character which, under the glass, in certain lights, gives a strong cancellate appearance to the ornamentation.

The dimensions of the neotype and plesiotype are as follows:

	Neotype. Partly testiferous (F.41409).	Plesiotype. (F.41412).
Length	19 mm.	19 mm.
Height	10 mm.	11 mm.
Thickness	7 mm.	8 mm.
Apical angle	134°	132°

Observations.—This small and distinct species is plentiful in a calcareous shale, 200 feet above the Greta Coal Seam, from the Caledonia Shaft, near Cessnock. A suite of similar shells has also been collected from similar strata in the Abermain No. 3 Shaft, also at Cessnock, New South Wales.

It has already been pointed out, in the discussion on *Nuculana concinna*, how that species is readily distinguished from *N. darwini*. In general outline the shells are somewhat similar, but the latter are smaller, possess more than double the number of ribs and are characterized by a definite cancellate ornamentation caused by an indistinct fine radial ribbing. *N. darwini* possesses a well-developed umbonal groove with two well-marked muscle scars. *Nuculana abrupta* is also characterized by a similar groove which contains two muscle scars, but it is impossible to confuse these two species. In discussing *N. abrupta*, mention was made of the similarity of the umbonal muscle scars with *N. bellistriata* Stevens, from the Wewoka Formation of Oklahoma. Girty (1915, p. 122) records in the American species a small strong scar, whereas in the Australian species two scars are developed. The groove in the latter, however, is restricted to the umbonal area, whereas in *N. bellistriata* the furrow is deeper and wider, and extends almost to the ventral border. The two small anterior and posterior pedal scars present in *N. bellistriata* are also found in *N. darwini*, and have been observed in *N. abrupta*.

Localities and Geological Horizon.—New South Wales: Caledonian Shaft, near Cessnock (Neotype and Plesiotype locality); Abermain No. 3 Shaft, near Cessnock (Lower Branxton Stage, Upper Marine Series). Railway Cutting between Maitland and Stony Creek (Branxton Stage, Upper Marine Series).

Nuculana etheridgei Johnston.

1886. *Tellinomya etheridgei* Johnston, Proc. Roy. Soc. Tasmania (1886), 1887, p. 17; Geology of Tasmania, pl. xv, fig. 14.

Holotype: The specimen described and figured by Johnston, from Upper Marine beds at the River Styx, Porter's Hill, Tasmania.

The original description of this species is as follows:

"Shell inequilateral, trigonal, elongately oval; concentric striae well defined; valves moderately convex; anterior side straight and somewhat truncate, rounded inferiorly; posterior slope longest, scarcely concave, produced to a sharp point; ventral margin gently curved, simple."

Height, 13 mm. Length, 27 mm.

Observations.—I have not examined any specimens of this species, but Johnston records it as being common in the Upper Marine beds at the River Styx, Porter's Hill, near Hobart, Tasmania. He states "this shell is easily distinguished from *N. darwini* by its more convex valves, and by its narrowly elongated form".

Cowper Reed (1932, p. 43) suspected that *Nuculana (Leda) thompsoni* from the Agglomeratic Slate of Kashmire is probably identical with *Nuculana etheridgei*. The Indian species, however, is of comparatively large size, and has an acutely-pointed posterior extremity. It is also nearly three times as long as high, and is quite distinct from any Australian species of the genus.

In general characters *Nuculana etheridgei* resembles *N. concinna* (Dana), but differs in the umbonal ridge of the former being decidedly concave; the inferior margin is strongly convex posteriorly and is produced upwards posteriorly to form a pointed extremity. In *N. concinna* the inferior margin is almost straight posteriorly and the extremity is more inferior than in *N. etheridgei*. A small internal cast in the Australian Museum Collection (F.37841) from the Linoproductus Horizon of the Macleay Series at "Colraine", Manning River, has been tentatively identified as *N. etheridgei*. It is only 14 mm. in length, height 7 mm., but agrees well with that species in most other respects.

Localities and Geological Horizon.—Tasmania: River Styx, Porter's Hill, near Hobart (Upper Permian). *New South Wales*: "Colraine", near Kimbriki, Manning River (Macleay Series, Permian).

Nuculana waterhousei Etheridge.

1888. *Nuculana waterhousei* Etheridge, Ann. Rept. Dept. of Mines, N.S.W., p. 168, pl., figs. 5–10.

Type Material: Specimens described and figured by Etheridge, from Wollombi Road Cutting, by Farley Railway Station, near West Maitland, New South Wales. Farley Stage, Lower Marine Series. The internal cast (figs. 7–8) is in the Australian Museum Collection, F.35413. The other specimens are mislaid in the Mining Museum Collection, Sydney.

This species has been adequately described and figured by Etheridge. As the publication may not be readily accessible to some workers, the description of the species is reprinted.

"Sp. Char.: Shell obliquely triangular-deltoid, obliquely produced posteriorly, valves convex in the umbonal region, rapidly declining to the ventral margin, which is sharp and knife-edged, the flanks sometimes slightly sulcate posteriorly. The dorsal margin arched and much shorter than the length of the valves; hinge teeth less than twelve on either side; cartilage pit apparently semi-circular. Ventral margin gently convex in the centre and in the direction of the anterior end, but slightly inflected towards the posterior. Anterior end, small, much more gibbous than the posterior, the margin obliquely rounded below, and insensibly disappearing. Umbones sharp, inrolled, and anteally incurved, flattened from above; escutcheon wide and well marked; pseudo-lunule defined by anterior rounded slopes. Muscular impressions large, the anterior close to the margin and rather low down; posterior scars prominent, thick at their

front ends. Ornamentation consisting of close, always more or less concentric, although variously directed, subimbricating, rather fluctuating, wavy, zig-zag, or V-shaped laminae, and at times abruptly faulted near the centre of each valve."

The dimensions of two of Etheridge's specimens are as follows:

	Fig. 6. (F.35408.)	Fig. 7. Paratype (int. cast). (F.35413.)
Length	26 mm.	23 mm.
Height	17 mm.	16 mm.
Thickness	12 mm.	11 mm.
Apical angle	105°	103°

Observations.—A great deal of variation is exhibited in the ornamentation of *N. waterhousei.* This has been described by Etheridge and rarely do two shells show the same pattern. The ribs are exceedingly fine and numerous, with no set pattern and usually very wavy.

The ornamentation, although it has some points of similarity with that found in the genus *Glyptoleda,* is of a different nature, and specimens of the two genera could never be confused. *N. waterhousei* is an outstanding species with high umbones, a rapidly declining posterior umbonal ridge, and the shell only half again as long as high.

An internal cast of a right valve, from the Ravensfield Sandstone, exhibits a narrow, well-defined groove extending from the apex of the umbo towards the inferior margin, gradually shallowing and widening and merging with the valve surface at the pallial line. Muscle scars are not developed in the groove. The pallial line is entire. A small pedal scar, attached to the anterior adductor scar by a fine, curved ridge, is situated near the cardinal line where the anterior set of teeth terminate.

The species is fairly abundant in the Farley Stage of the Lower Marine Series and is also known from the Ravensfield Sandstone. Two specimens collected by Voisey (1939, p. 250) from the Macleay Series in the Manning River district of New South Wales belong to this species.

Localities and Geological Horizons.—New South Wales: Railway cutting near Farley, Wollombi Road, by Farley Railway Station, near West Maitland (Farley Stage, Lower Marine Series). Ravensfield (Ravensfield Sandstone, Farley Stage, Lower Marine Series). "Colraine", near Kimbriki, Manning River (Macleay Series, Lower Permian).

Nuculana undulostriata sp. nov.

1907. *Nuculana waterhousei* Etheridge, (?) var. Off. Contrib. Pal. of South Aust., No. 18, p. 6, pl. v, figs. 10–11, Supplement to S.A. Parl. Paper No. 55 of 1906.

Holotype: Specimen described and figured by Etheridge, from Fossil Head, Treachery Bay, northern Australia. Its whereabouts is unknown.

Etheridge described a shell from the Permian beds of Fossil Head, Treachery Bay, as a probable variety of *Nuculana waterhousei,* because of the "sculpturing which consists of irregular fluctuating, or V-shaped concentric, and not too close lines". He thought it could be considered a variety of that species, but in my opinion other outstanding differences prove it to be a distinct species and I have named it *N. undulostriata.* A single imperfect specimen, L36 (3), of both valves, from the Minilya River, is tentatively referred to this species. The general outline of *N. undulostriata* differs entirely from *N. waterhousei,* a characteristic species in which the umbones are prominent and elevated. The antero-dorsal margin and the posterior umbonal ridge slope rapidly downwards from the umbones, whereas in *N. undulostriata* these slopes are not at all pronounced. The apical angle of *N. waterhousei* is about 150° and in the present species, after an examination of the specimen figured by Etheridge (pl. v, fig. 10), would be at least 140°. The ornamentation agrees with *N. waterhousei* in being wavy, but apart from that is dissimilar. The ribs on *N. undulostriata* follow a more or less concentric pattern, whereas in *N. waterhousei* the ornamentation is generally concentric on a narrow zone near the inferior margin but above that the ribs are arranged diagonally.

The specimen from the Minilya River is very similar to *N. undulostriata* in its ornamentation but, nearing the posterior umbonal ridge, the concentric ribs bend abruptly upwards. The posterior portion of this shell is damaged and an indication of this feature only can be discerned. The curved arrangement of the ribs on the inflated anterior flank, figured by Etheridge (pl. v, fig. 11), is also present but the bases of the curves are more acute.

This species is approximately 20 mm. in length and 15 mm. in height. It cannot be confused with *N. basedowi* with which it is associated in the Bulgadoo Series, as in that species the anterior two-thirds of the valve is inflated, the posterior portion is flattened, while the posterior umbonal ridge descends at a fairly steep angle to the extremity of the inferior margin. In *N. undulostriata* the posterior umbonal ridge is abbreviated and the posterior extremity is rounded and not pointed as in *N. basedowi.*

Localities and Geological Horizon.—Western Australia: Southern bank of the Minilya River, near Bulgadoo Pool, 3,380 yards N. 110° W. from Bulbawardoo Windmill. Probably upper part of the Bulgadoo Series. *North Australia*: Fossil Head, Treachery Bay, Victoria, River estuary. Permian (stratigraphy unknown).

Nuculana basedowi Etheridge.

(Plate xxii, figs. 6–7.)

1907. *Nuculana basedowi* Etheridge, Off. Contrib. Pal. of South Aust., No. 18, p. 8, pl. vi, fig. 6. Supplement to S.A. Parl. Paper No. 55 of 1906.

Holotype: Specimen described and figured by Etheridge from Fossil Head, Treachery Bay, northern Australia. Its whereabouts is unknown.

The original description of this species is as follows:

"Shell (replacement) obliquely triangular, very inequilateral, prolonged or nasute posteriorly, moderately convex, the greatest convexity in a line below the umbone. Dorsal margin concave (posteriorly)—convex (anteriorly); dorsal area somewhat concave, umbos sub-median, depressed. Ventral margins gently rounded; anterior ends rather compressed, the margins obliquely rounded; posterior ends much produced, nasute, gradually contracting between dorsal and ventral, and gradually compressed transversely, or through the valves. Sculpture consisting of fine and very close regular concentric lines."

Etheridge stated that the form and dimensions of his species are quite sufficient to separate it from *Nuculana waterhousei* and from *Nuculana* sp. described by him (1892, p. 273) from the Star River Carboniferous beds of Queensland. Etheridge says "as a matter of fact, except for its size, it presents greater analogy with the little unnamed Queensland fossil, which was, unfortunately, only an external impression".

I have not examined any of the type material of *N. basedowi*, but Dr. Curt Teichert, of the University of Western Australia, forwarded me six specimens from the Upper part of the Bulgadoo Series, at Wandagee Station in the North-West Division, Western Australia, which in my opinion must be referred to this species.

The following characters have been compiled from these specimens:

Shell elongated, inequilateral. Anterior part of the shell strongly inflated in the umbonal region, becoming flattened and compressed posteriorly. Anterior end oval, produced inferiorly. Inferior margin broadly convex directed upwards posteriorly to meet the rapidly declining umbonal ridge in a bluntly-rounded posterior extremity. The umbonal ridge increases in width towards the bluntly-pointed posterior extremity.

Umbones contiguous, depressed, recurved posteriorly. On internal casts, a shallow umbonal groove extends for a short distance ventrally and backwards from the apex, but is devoid of muscle scars. Anterior to the umbo a deep narrow lunule is developed while posterior to it a very narrow elongated escutcheon is present. This is divided into an inner portion, ornamented with fine longitudinal striae, and an outer portion sculptured with a continuation of the surface ribs which bend sharply forward as they cross the umbonal ridge. The distinct ridge usually found separating the escutcheon into two portions is not developed.

The valves are sculptured with 50–60 concentric ribs, closely packed on the umbonal slope, but becoming more widely separated near the inferior margin.

The dimensions of two specimens are as follows:

	L.36(1).	L.36(2).
Length	23 mm.	14 mm.
Height	16 mm.	9·5 mm.
Thickness	13 mm.	9 mm.
Apical angle	124°	123°

Cowper Reed (1932, p. 43) suspected that *Nuculana* (*Leda*) *thompsoni*, from the Agglomeratic Slate series on Bren Spur, Kashmir, may have strong affinities with *N. basedowi*, but it would be difficult to be confused between the two species. The former is an outstanding species and could not be compared with any Nuculanid in Australian Permian rocks.

Thomas (1928, p. 216) in describing an "Upper Carboniferous" fauna from N.W. Peru, included *Leda browni* and made analogies with *Nuculana basedowi*. He said it closely resembled the Australian form, but differed in its longer and less quadrate anterior end, and its more elevated umbones.

Nuculana basedowi is a characteristic form and cannot be confused with other species of the genus. It is strongly inflated in the median umbonal region and compressed in the posterior one-third of the shell.

Localities and Geological Horizon.—Western Australia: Fossil Head, Treachery Bay, Victoria River estuary, north Australia. Permian (stratigraphy unknown). On the south bank of the Minilya River, near Bulgadoo Pool, 3,380 yards N. 110° W., from Bulbawardoo Windmill (probably Upper part of the Bulgadoo Series).

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EXPLANATION OF PLATES.

PLATE XIX.

Glyptoleda reidi sp. nov.

Figs. 1-3.—The holotype (F.41404). 1. Left valve showing outline and ornamentation. 2. Right valve. 3. Dorsal view.

Figs. 4-5.—Slightly weathered paratype (No. 265). 4. Right valve. 5. Dorsal view.

Fig. 6.—Internal cast of a left valve (F.36431).

Glyptoleda coleyi sp. nov.

Fig. 7.—The holotype [No. J.35(2)]. Right valve showing characteristic outline and ornamentation. The valve is weathered near the inferior margin revealing concentric growth lines.

Fig. 8.—Right valve of a smaller specimen (No. J.44).

Fig. 9.—Dorsal view of a cast of both valves [No. T.168(1)]. The teeth, and outer series of small pits marking the position of the ridge which separates the escutcheon into two portions, are clearly shown.

PLATE XX.

Glyptoleda glomerata sp. nov.

Figs. 1-3.—The holotype (F.41405). 1. Left valve showing outline and ornamentation. 2. Right valve. 3. Dorsal view.

Nuculana ovata Laseron.

Figs. 4-6.—The holotype (F.20176). 4. Right valve showing ornamentation. 5. Decorticated left valve. 6. Dorsal view.

Fig. 7.—Right valve of a smaller specimen (F.41406).

Fig. 8.—Dorsal view of a cast of both valves (F.41407) showing dentition.

PLATE XXI.

Nuculana darwini (De Koninck).

Fig. 1.—The neotype (F.41409). Left valve showing closely arranged ribbing and cancellate appearance of the ornamentation.

Fig. 2.—Dorsal view of a cast of both valves (F.41412), showing anterior adductor and pedal muscle scars. The furrow, corresponding to the ridge on the inside of the valve, may be seen on the umbo of the right valve.

Nuculana ovata Laseron.

Fig. 3.—Dorsal view of a small specimen (F.41406).

Nuculana abrupta (Dana).

Fig. 4.—A plastotype (after Dana), L.670, showing left valve partly covered with matrix.

Figs. 5-6.—Partly decorticated specimen (F.24240). 5. Left valve showing traces of concentric ornamentation. High on the flank of the umbo the groove or furrow containing two small muscle scars is present. 6. Dorsal view.

PLATE XXII.

Nuculana darwini (De Koninck).

Figs. 1-2.—Cast of both valves (F.41412). 1. Decorticated left valve showing pallial line and notched posterior adductor muscle scar. 2. Partly decorticated right valve showing shallow groove and muscle scars on umbonal flank.

Nuculana concinna (Dana).

Fig. 3.—A plastotype (after Dana) L.671, showing the imperfect shell from which the species was described.

Figs. 4-5.—The plesiotype (F.39313). 4. Partly decorticated left valve showing general outline and ornamentation. 5. Dorsal view showing lunule and escutcheon.

Nuculana basedowi Etheridge.

Fig. 6.—A left valve [L.36(1)] showing ornamentation and characteristic outline of the species.

Fig. 7.—A right valve [L.36(2)] showing the inflated anterior portion and the smaller, flattened, posterior portion.

Photographs by G. C. Clutton.

A NEW *AULOSTEGES* FROM THE LOWER PERMIAN OF QUEENSLAND.

By H. O. Fletcher,
The Australian Museum, Sydney.

(Plate xxiii.)

Introduction.

In this paper a new species of *Aulosteges* from the Dilly Stage of the Queensland Permian is described as *Aulosteges acanthophorus*. It is the first time the genus has been recorded from the Permian rocks of Eastern Australia, although it is not uncommon in rocks of similar age in Western Australia.

Some time ago a comprehensive collection of fossils was made by Mr. J. H. Reid, Geological Survey of Queensland, from the Permian beds of the Springsure district. The collection was later presented by him to the University of Queensland, Brisbane. Included in this collection are two well preserved specimens of *Aulosteges*, now known as *A. acanthophorus*, and consisting of a complete shell (No. 153) and an internal cast of a brachial valve (No. 152). They were collected from "Little Gorge Creek, Springsure Anticline, Queensland". This species has since been collected from the head of Little Gorge Creek and from the Burnett River, half a mile south of Yarrol, Queensland.

I am indebted to Mr. J. H. Reid for the opportunity of describing this new and interesting species of *Aulosteges*, and to the Shell (Queensland) Development Proprietary Ltd., for information regarding the additional localities.

The Occurrence of Aulosteges in Australian Rocks.

The genus *Aulosteges* is restricted to rocks of Permian age and has practically a world-wide distribution. It was first recorded in Australia when Etheridge (1903, p. 22) described *A. baracoodensis* from Baracooda Pool, Arthur River, North-West Division, Western Australia (Callytharra Stage). The same author ((1906, p. 5) later described *A. baracoodensis* var. *septentrionalis*, from a locality six miles north-east of Cape Dombey, Hyland Bay, Northern Territory.

Etheridge (1914, pp. 33–34) described and figured two additional specimens of *A. baracoodensis* from twenty miles north of Barrabiddie, Minilya River district, but Whitehouse (1926, pp. 282–283) considered these particular specimens should be referred to *Taeniothaerus*. This genus was proposed by him for shells previously known as *Productus subquadratus* of Morris. Miss Hosking (1933, p. 36) is of the opinion that the specimen figured by Etheridge (1914, pl. iv, figs. 11, 13) should be referred to *Taeniothaerus subquadratus*, but the second specimen (pl. iv, fig. 12), which actually came from Mt. Marmion, must be retained in the genus *Aulosteges*. Miss Prendergast (1943, p. 27) placed both specimens as synonyms of *Taeniothaerus subquadratus*.

Miss Hosking (1931, p. 15) described and figured *A. ingens*, a large inflated species, from the Wooramel River, two miles east of Survey Station R.20 and from a locality three miles above Survey Station R.20 (Byro Stage). A series of well preserved specimens of this species, in the Australian Museum Collection (F.36213–7), were collected by Dr. H. Raggatt from a locality thirty chains below Coolkilya Pool, Minilya River (Wandagee Stage). Additional specimens were collected by Mr. H. Coley of Wandagee Station. This locality is approximately 150 miles north from the Wooramel River. A smaller species with shallow valves, *A. spinosus*, was described and figured (Hosking, 1931, p. 17) from the south bank of the Wooramel River, below Callytharra Springs (Callytharra Stage). Later, the same authority (1933, pp. 33–37) revised the

known species of *Aulosteges* from Western Australia with some additional notes on *A. baracoodensis*. Little known records of the genus and specimens that cannot be traced were also listed. A specimen, *A.* cf. *spinosus*, from the Irwin River (Fossil Cliff limestone) was recorded. The brachial valve of *Aulosteges*, F.16779 in the Australian Museum Collection, from the Lower horizon of Mount Marmion (1933, p. 36) can certainly not be referred to *A. baracoodensis*. It must, however, be retained in the genus *Aulosteges*.

Miss Hosking (1933, p. 37) also described a specimen from Luluigui Station, Kimberley Division, as *Aulosteges* sp. (Upper Ferruginous or Liveringa Series). An additional specimen, with the umbo curved over and concealing the pseudo-deltidium was also mentioned from the same locality.

The morphology of the genus *Aulosteges* was dealt with by Miss Prendergast (1943, pp. 32–37) and comparisons were made with closely allied genera. Two specimens of *A. spinosus* were also described from Wandagee Station, Minilya River, which extended the range of this species into the Wandagee Stage.

The present known species of the genus *Aulosteges* occurring in the Permian rocks of Australia are as follows:

Aulosteges baracoodensis Etheridge.
„ *baracoodensis* var. *septentrionalis* Etheridge.
„ *ingens* Hosking.
„ *spinosus* Hosking.
„ sp.
„ *acanthophorus*, sp. nov.

Description of the Species.

Genus Aulosteges Helmersen.

1847.—Helmersen. Leonhard and Bronn's Jahrbuch für Mineralogie, p. 331, text-figure.

Aulosteges acanthophorus, sp. nov.

(Plate xxiii, figures 1–3.)

Shell of medium size, sub-quadrangular in outline, slightly longer than wide. Moderately convex pedicle valve and flattened brachial valve with strongly vaulted margins. Hinge-line straight, exceeding two-thirds the greatest width of the valve. Surface of the valves uniformly marked with rather sparse, stout spines varying little in size and strength.

The pedicle valve is convex, not strongly inflated with a shallow sinus originating at about the middle of the shell, in the central line, and increasing in width towards the slightly indented inferior margin. Longitudinally the valve appears somewhat flattened but bends suddenly in a well-rounded curve to form abruptly sloped, straight, lateral and inferior margins. The slope at the junction of the lateral and cardinal margins is not so strongly marked, almost flattened, forming distinct auricles.

The umbo is prominent, produced, pointed, overturned and slightly twisted, overhanging the area. A distinct scar on the umbo may represent the point of attachment to some foreign body but on the other hand could have been caused during preservation of the shell. The area is widely triangular, not high, and appears to be unequally developed on the two sides of the pseudo-deltidium. The area is slightly concave and is marked with vertical striations. A narrow pseudo-deltidium is present immediately below the umbo, but for the most part is hidden by the overhanging umbo and the central point produced on the cardinal margin of the brachial valve.

The surface of the pedicle valve is ornamented by not very numerous but regularly arranged and evenly spaced stout, erect and rounded spine bases. These bases continue longitudinally for some distance in the test before emerging at the surface. They give the valve a false ribbed appearance. The remains of several spines prove them to have attained considerable length. They are slightly finer on the umbonal slope but become thick and heavy on the lateral margins, and particularly the inferior margin. The

surface of the valve, between the spine-bases, is crowded with minute perforations. Concentric lines of growth are numerous, more pronounced at the inferior margin.

The brachial valve is more or less flat in the visceral region and along the cardinal margin, otherwise concave with strongly geniculated margins. The cardinal margin is almost as wide as the valve and is produced laterally to form auricular or triangular expansions.

The cardinal process is missing from the internal cast of the brachial valve. The appearance of the base suggests it was fairly strongly developed, not of great length, and the angle of inclination to the cardinal margin was wide.

A distinct median septum originates at the base of the cardinal process and extends for about two-thirds the length of the valve. On each side of this septum two roughly oval adductor muscle scars are found, with dendritic markings. Brachial impressions are not preserved.

The external surface of the brachial valve possesses fine spine-bases, compared with the pedicle valve, and these are not numerous. The entire surface, with the exception of the visceral area, is covered with minute perforations or possibly spine-bases for hair-like spines. These are particularly abundant on the vaulted margins. The internal surface is smooth except where the shell substance has been partly removed and reveals the bases of the spine sockets.

The dimensions of the specimens are as follows:

	Fig. 1.	Fig. 2.
Length	68 mm.	62 mm.
Width	66 mm.	62 mm.
Hinge-line	48 mm.	42 mm.

Observations.—The species of *Aulosteges* known from Western Australia fall into two types. One of these with strongly inflated pedicle valves and steep sides is represented by species such as *A. ingens* and *A.* sp., while *A. baracoodensis* is representative of a type characterized by pedicle valves with a low degree of convexity and more or less sloping sides. The Queensland shell, *A. acanthophorus*, has a low degree of convexity with steep sides. It differs from *A. baracoodensis* in being far more quadrate in outline, having a low area, and in possessing sparsely arranged, thick spine-bases on the pedicle valve. The present species appears to be somewhat related to *A. baracoodensis* var. *septentrionalis* as they both possess regularly arranged coarse spines. They differ widely, however, in other respects. The general outline in *A. acanthophorus* is more quadrate and the cardinal process is of the *A. baracoodensis* type with an elongated extension into the umbo.

Miss Hosking (1931, p. 16) states that the area in *A. ingens* is "unequally developed on the two sides of the pseudo-deltidium". This is actually the case in *A. acanthophorus*, but I feel sure this feature has been developed by pressure on the brachial valve during preservation of the shell.

Localities.—Little Gorge Creek, Springsure district; Burnett River, half a mile south of Yarrol, Queensland.

Horizon.—Lower Permian. (Dilly Stage.)

Collection. University of Queensland, Brisbane. No. 153, Holotype; No. 152, Paratype.

Stratigraphical Conclusions.

The occurrence of *A. acanthophorus* in the Permian rocks of Queensland considerably extends the distribution of the genus in Australia as previously it was thought to be restricted to Western Australia. It is possible that as further research is carried out on the Permian faunas of Eastern and Western Australia many additional forms may be found which will suggest that the relationship between these beds is closer than is usually considered. It is useless to depend on the published lists of fossils made many years ago, but as new collections are made and described I feel sure that the dissimilarity between the two faunas will prove to be not so nearly marked as was originally thought.

The specimens of *A. acanthophorus* from Little Gorge Creek and from the Burnett River, near Yarrol, are so similar that I venture to suggest the beds may be correlated as being horizontally equivalent. The associated fauna at Yarrol can also be compared favourably with species found at Little Gorge Creek which Reid has placed as belonging to the Dilly Stage. The fossil horizon at Yarrol has been correlated with the Gympie formation, a formation whose stratigraphical position is rather vague. Previously suggested as Upper Carboniferous age by a number of authors, the Gympie Series was finally considered to be Permian in age by Raggatt and the author (1937, p. 159). Recent field-work has proved the Dilly Stage of the Lower Bowen Series to be at the base of the Series so that a correlation of these beds, through *A. acanthophorus*, with the Yarrol fossil horizon is convincing.

In Western Australia the genus has a long vertical range extending from the Callytharra to the Wandagee Stage in the North-West Division and their equivalents in other areas. The species are also found to range through several horizons so that an attempt to correlate *A. acanthophorus* with allied forms in Western Australia is unsatisfactory.

The larger, inflated forms such as *A. ingens* from the Byro and Wandagee Stages, and *A.* sp. from the Upper Ferruginous or Liveringa Series appear to be restricted to horizons fairly high in the Permian sequence. The other more shallow-valved species such as *A. baracoodensis* and *A. spinosus*, with which the Queensland shell is more comparable, first appear in the Callytharra Stage and the Fossil Cliff limestone but are also found in higher horizons. The detailed stratigraphy of the Permian beds between the Victoria and Daly Rivers in the Northern Territory is unknown, so that the stratigraphical position of *A. baracoodensis* var. *septentrionalis* must remain in doubt until further field-work is carried out in this area.

Miss Prendergast (1943, p. 4) points out that in *Aulosteges* "the area is linear in the earlier species, but rapidly develops among the later species to a high plane triangle produced ventrally and thus carrying the umbo of the pedicle valve away from the brachial valve". In *A. acanthophorus* the area is narrowly linear and the umbo of the pedicle valve almost overhangs the pointed cardinal process of the brachial valve. If this feature may be taken as an indication of a primitive shell, then the Queensland species must be younger than *A. baracoodensis* and *A. spinosus*, as both these species, have the area developed ventrally, to a far greater extent than in *A. acanthophorus*.

Any attempted correlation between *A. acanthophorus* and Western Australian species of *Aulosteges* is inconclusive and tentative. It may be that the Queensland shell is a more primitive type than any found in Western Australia. If this is the case the Dilly Stage of Queensland would be pre-Callytharra or pre-Fossil Cliff and a correlation could be looked for in the top-beds of the Lyons Series.

EXPLANATION OF PLATE XXIII.

Aulosteges acanthophorus sp. nov.

Fig. 1.—Pedicle valve. Holotype, No. 153.
Fig. 2.—Dorsal view of Fig. 1, showing brachial valve and area of pedicle valve.
Fig. 3.—Interior of brachial valve; cardinal process not preserved. Paratype, No. 152.
Natural size.
G. C. Clutton, photo.

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PLANKTONIC CEPHALOPOD LARVAE FROM THE EASTERN AUSTRALIAN COAST.

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(Plates xxiv–xxvii, and Map.)

Introduction.

The larval cephalopod material upon which this report is based was obtained in plankton hauls of the Research Ship *Warreen* along the eastern Australian coast in 1938–1941, during investigations by the Fisheries Division, Council for Scientific and Industrial Research. I am indebted to Dr. H. Thompson, Chief, Fisheries Division, for the opportunity to report on this interesting and unusual material, and to Dr. D. L. Serventy and Mr. K. Sheard for help in matters relating to stations, depths and other factors associated with the collection. My thanks are also due to Miss Betty McKinnon, Lands Department, Sydney, for preparation of the map.

The material is extremely important in the study of this molluscan class. One hundred and thirty specimens examined from stations over an area extending from Port Arthur, S.E. Tasmania, to Heron Island, Great Barrier Reef in the north, represented 13 families, 19 genera, and 20 species, a number of which are bizarre forms belonging to families hitherto unrecorded from the South Pacific. The minute size, delicate nature, and rarity of the majority of specimens permitted only the simplest dissection in a few cases. Practically all forms appear quite larval and no signs of hectocotylization were evident.

Character and Relationships.

A surprising feature of the collection is the large number of families represented by only a single specimen, the only species occurring in any considerable number being *Pyrgopsis pacificus* (Issel), and the larval *Rhyncoteuthion* form of an Omnastrephid, *Nototodarus gouldi* (McCoy), young of which are removed at times from the stomachs of Tuna taken off this coast. The almost certain association of this larva with the adult *gouldi* has proved one of the most interesting surprises in the collection. The predominance of Oegopsid and the scarcity of Myopsid cephalopods are very marked, only three species of the latter suborder being present.

Another striking feature is that, with few exceptions, the new or little known species either belong to genera previously known only from a comparatively small area in another part of the world or to genera with a wide range. For instance, the appearance on this coast of the extraordinary little species *Ctenopteryx sicula* Appellof, hitherto known only from the Mediterranean and North Atlantic regions, is most surprising. Similarly, the appearance of the genera *Tetronychoteuthis* Pfeffer (Atlantic), *Mastigoteuthis* Verrill (Atlantic and Pacific), and *Heteroteuthis* Gray (Mediterranean, East Indies, Hawaii), and the occurrence of the family Bolitaenidae, represented by only a single specimen, so far south of its known Pacific range, gives a new aspect to our cephalopod fauna.

On the other hand, the appearance of *Brachioteuthis riisei* in a local collection for the first time, further extends its already wide range, and gives support to Hoyle's statement (1912, p. 338), that this curious little pelagic species will eventually prove to have an almost universal range. In contradiction to the presence of these unusual forms, so far removed from their accepted range, some rare species have been found

in close proximity to their type localities in the Australian region, e.g. *Idiosepius notoides* Berry, *Euprymna tasmanica* Pfeffer, *Calliteuthis miranda* Berry, and *Amphitretus pelagicus* Hoyle. Only a few of the species in the collection had been previously taken by the *Challenger*, *Endeavour* and *Terra Nova*.

Far too little is yet known of the Australian cephalopod fauna, and material in the present collection is too scanty to permit generalizing with any degree of safety on its zoo-geographical relationships with that of other regions. It will be seen, however, that a definite Mediterranean affinity exists in the case of one species at least, and a number of species have Atlantic and North Pacific forms as their nearest allies. A leaning towards the Japanese fauna, and possibly a closer affinity with the Hawaiian planktonic cephalopods, is noticed. Regarding relationships in the home waters, two examples may be quoted. The presence of *Amphitretus pelagicus* off S.E. Tasmania associates that region with the Kermadecs, and similarly *Pyrgopsis pacificus*, from stations extending from S.E. Tasmania to Coffs Harbour, north coast of New South Wales, indicates a correlation between our eastern coastal waters and those of north New Zealand, whence the species has already been recorded.

Classification.

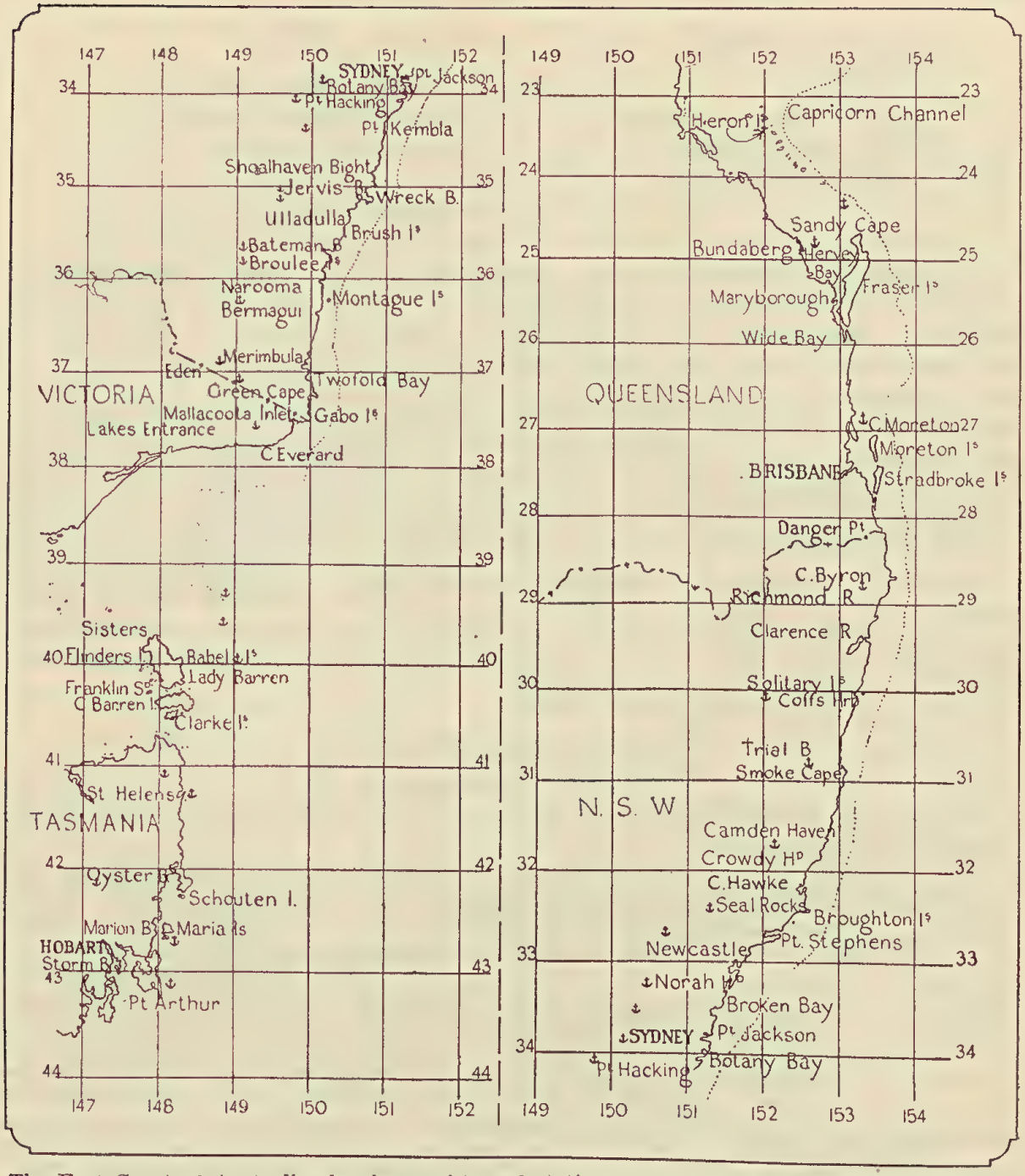
The only comprehensive work on Australian planktology is the monograph by Dakin and Colefax (1940), an excellent guide for the identification of planktonic organisms of Australian coastal waters off New South Wales, which I have found most helpful for general planktonic conditions, during the preparation of this paper. No cephalopods are included in this monograph; the authors indicated that although molluscan larvae play an important part in the plankton, especially near the coast (p. 205), they found that the occurrence of young cephalopods on odd occasions was so spasmodic that it was not considered worth while to include them in the work.

No work especially devoted to Australian planktonic cephalopods has yet appeared; indeed, published work on Australian Cephalopoda generally has been almost negligible. A considerable search through scattered volumes, in which many descriptions are brief and many species unfigured, has therefore been necessary. The investigations of the *Challenger*, *Endeavour*, *Terra Nova* and others, though providing us with a few species, barely touched the cephalopod fauna of these coastal waters. In particular, the works of Chun, Pfeffer, Hoyle, Berry, Sasaki, and Thiele, whose general lines of classification I have followed, have been the main source of investigation. Where Thiele and modern authors have differed I have endeavoured to point this out, and have adopted the name which I think applies more satisfactorily to our species. Some of the specimens named tentatively may later prove to be new species; one or two others may be better placed in an allied genus, but on a single or perhaps two larval specimens, without other material for comparison, it seems wiser to ally them to the species they most closely resemble than to propose new species for perhaps geographical reasons only. On the other hand, where a species does not conform to others in characters which appear specifically constant, as with two species, I have considered them new.

Since the international situation at the present time prevents the elucidation of many points connected with a paper of this nature, I will welcome opinions concerning the classification of the rare forms obtained in these hauls, as the opportunity occurs. Undoubtedly many taxonomic problems exist with regard to the planktonic cephalopods, some of which have been encountered in working over the material, but the main object here is to place on record the existence of larval forms whose genera or even families were previously unrepresented in Australian waters. For this reason each species has been figured as a quick initial guide in identification.

Distribution.

At the suggestion of Mr. K. Sheard, the *bathymetrical* distribution is indicated as *shallow* and *slope* (*deep*), for the purpose of this report. As will be seen from the table below, some of the species occur in both distributions.



The East Coast of Australia showing position of stations (indicated by anchors) from which cephalopods were obtained.

Shallow.	Slope.
Euprymna tasmanica Pfeffer	
Heteroteuthis serventyi sp. nov.	
Idiosepius notoides Berry	
Abralia ?astrosticta Berry	
Abraliopsis ?hoylei Pfeffer	*Abraliopsis hoylei* Pfeffer
Pterygioteuthis giardi Fischer	*Pterygioteuthis giardi* Fisch.
Onychoteuthis ?rutilus Gould	*Onychoteuthis ?rutilis* Gould
Tetronychoteuthis ?massyae Pf.	
Brachioteuthis riisei (Steen.)	*Brachioteuthis riisei* (Steen.)
	Ctenopteryx sicula Appellof
	Nototodarus gouldi (McCoy)
Rhyncoteuthion, larvae of	*Rhyncoteuthion*, larvae of
Nototodarus gouldi (McCoy)	*Nototodarus gouldi* (McCoy), 85%
	Calliteuthis miranda Berry

Shallow.	Slope.
Mastigoteuthis grimaldi (Joubin)	
	Bathothauma lyromma Chun
Pyrgopsis pacificus (Issel)	*Pyrgopsis pacificus* (Issel), 70%
Octopus ?pallida Hoyle	*Octopus ?pallida* Hoyle
Octopus ?tetricus Gould	
	Eledonella sheardi sp. nov.
	Amphitretus pelagicus Hoyle

No conclusion regarding *seasonal distribution* could be deduced from this small collection. With regard to local *geographical distribution*, apart from those species indicated in the text as having increased their Australian range, the distribution up the coast from Twofold Bay, New South Wales, to southern Queensland, of the *Rhyncoteuthion* larval form of the common squid, *Nototodarus gouldi*, is most interesting, since it is the first record of this larva along the eastern Australian coast. Similarly, the progression through numerous stations from Tasmania to the north coast of N.S.Wales, of *Pyrgopsis pacificus*, the most abundant species in the collection, previously unrecorded from the South Pacific except for two specimens off north New Zealand, provides a striking instance of the unusual cephalopods existing in our waters.

As this is the first paper to appear on Australian planktonic cephalopods, its possible value as a means of identification for the general planktonic worker, as well as a record, from a purely conchological aspect, of new and interesting material added to our list, has been taken into consideration. Keys and family characters, therefore, have been included to simplify identification.

Class CEPHALOPODA.

Subclass Dibranchia.

Two orders of dibranchiate Cephalopoda are represented in the collection, distinguished by the following key:

a. Animal generally with elongate body, pointed posteriorly, fins present, well developed. Ten arms (two tentacular arms): suckers pedunculate, with horny chitinous rings. Suckers sometimes replaced by hooks. Head and mantle often free in nuchal region. Gladius rarely absent. Highly specialized photogenic organs of many types often present .... Order *Decembrachiata* (*Decapoda*)

b. Eyelids perforate over the cornea. Suckers frequently transformed into hooks. Photogenic organs often present on or within the body .. Suborder *Oegopsida*

bb. Eyes almost invariably covered by imperforate membrane. Horny rings to suckers, either smooth or dentate. No hooks on arms. Photogenic organs usually absent but may occur in mantle cavity ..... Suborder *Myopsida*

aa. Animal normally with short body, rounded posteriorly, fins absent or very rudimentary. Arms similar in appearance, eight in number. Suckers sessile, without chitinous rings. Head and mantle continuous in nuchal region. Gladius absent. Specialized photogenic organs rarely present ..... Order *Octobrachiata* (*Octopoda*)

Winckworth (1932, p. 248, 251) proposes *Decembrachiata* Latreille as a substitute for the order Decapoda Leach 1817, to avoid confusion with the crustacean order Decapoda and, for symmetry, alters Octopoda to Octobrachiata. Bouxin and Legendre (1936, p. 12) and Cotton and Godfrey (1940, p. 370, 442) follow this substitution.

Suborder Oegopsida.

Family Enoploteuthidae.

Animal small to moderate size. Fins sagittate or rounded, terminal or subterminal. Arms with two rows of suckers and hooks; tentacle clubs little or not at all expanded, their suckers in four rows, usually part of them transformed into hooks (suckers only are found in the young of some genera). Photophores almost invariably present on the ventral surface of the eyeball and in addition may occur within the mantle cavity or scattered over the outer integument. Buccal membrane eight-pointed. Gladius plume-shaped with broad wings and no end cone.

Distribution.—Atlantic, Pacific, and Indian Oceans, Mediterranean.

Two subfamilies are represented in the collection, the characters of which are as follows:

a. Body roundly pointed posteriorly, extending very little or not at all beyond fins. Fins large and usually sagittate, not separated. Tentacles with a row of hooks in adult. Photogenic organs often in large numbers on ventral aspect of mantle and usually on head and arms: almost invariably present as single series of large organs on ventral eyeballs. No luminous organs in pallial chamber ..... *Abraliinae*

aa. Body sharply pointed posteriorly, notably exceeding fins. Fins rounded, separated. Photogenic organs lacking from outer integument, but numerous on eyeball as well as within pallial chamber ..... *Pyroteuthinae*

I have followed Thiele in using the name Abraliinae rather than Enoploteuthinae.

Subfamily Abraliinae.

Genus Abralia Gray, 1849.

Abralia Gray, 1849, p. 46, 50. Type, *Onychoteuthis armata* Quoy & Gaim., 1832 (species first mentioned), near Island of Celebes.

Fins large, somewhat sagittate. Arms with two rows of hooks for greater part of length, but with true suckers at tips. Dorsal row of suckers on proximal portion of tentacle club suppressed in adult, leaving one row of hooks and two rows of suckers which give way to four rows of suckers distally.

This is the first record of the genus from Australia.

Abralia ?astrosticta Berry, 1909.

(Plate xxiv, figs. 1–10.)

Abralia astrosticta Berry, 1909, pp. 412, 419. Type locality, Oahu, Hawaiian Islands.

Animal small, firm and rounded. *Mantle* almost equal width for more than half its length, gradually sloping off to roundly pointed tail; margin only slightly raised mid-dorsally, otherwise straight except for two slight points ventrally indicating position of *interlocking system*, with slight emargination between them. *Fins* about two-fifths length of mantle, fairly wide. *Head* large, about as wide as mantle and almost half its length. *Eyes* set far apart and high up, separated ventrally by a fairly wide groove. *Siphon* reaching to about lower level of eye area, hooded, attached to head by two bands; valve within. Two elongated ridge-like pustules on each *olfactory crest.*

Arms broad, long, flattened and strong; order 2, 3, 4, 1. Third and fourth pairs with thin wavy membranes along outer edges. Ventral pair widened conspicuously at base. *Suckers* well developed, in two slightly oblique rows replaced in part further down the arm by a few conspicuous hooks and mounds enclosing hooks. Dorsal pair has about 13 rows of suckers and 2 spine mounds; second pair has about 12 rows of suckers and a single sucker (fig. 3); about the same arrangement on the 3rd pair of arms; and on the ventral arms are 14 rows of suckers only. *Tentacular arms* long and well developed, *clubs* forming about one-third length of exposed tentacle. Suckers *only* present on clubs, due doubtless to immaturity of specimens. First six rows of suckers small, increasing rapidly in size in the next six rows of slightly stalked suckers. Suckers on clubs arranged in rows of four, except the last three rows which contain three, two, and one respectively. Suckers on both arms and tentacular clubs appear to have serrated edges.

Gladius shown as a dark streak mid-dorsally. Typical *Abralia* shape, thickened mid-rib, tapering anteriorly to a fine point posteriorly, wings very delicate, widening considerably half-way down, gradually sloping to a rounded, slightly inturned point posteriorly.

Body, in particular the ventral surface, studded with small but conspicuous *photogenic organs* in more or less regular rows on the mantle, siphon, head, and along backs of arms: inconspicuous dorsally. A few larger *photophores* surround the ventral surface of eyes.

Colour.—General colour dark buffish-brown, with rather large chromatophores round the head and along the dorsal surface of mantle. Photophores appear dark bluish colour.

Measurements.—Mantle margin to tail tip, 10 mm. long, 5 mm. broad. Fins, 6 mm. complete width, 3 mm. high. Head, 4 mm. long, 4 mm. broad. Dorsal arm, 5 mm. long, 2nd pair 7 mm. long, 3rd 6 mm. long, ventral arms 5 mm. long, 1 mm. broad at base. Tentacular arms, 9 mm. long, 1 mm. broad.

Locality.—Station 201/39. 17/7/39. N.70. D.25. Obl. (off Coffs Harbour, N. Coast, N.S.Wales). Shallow. 1 specimen (figured). Station 221/39. 16/9/39. N.200. Hor. D.O. 15 mm. 31°17′S., 153°34′E. (near Smoky Cape, North Coast, N.S.Wales). Shallow. Two specimens about same size and similar in appearance to above, have small dark brown marks along arms.

Remarks.—The genus *Abralia* has not been recorded from eastern Australia, and it is with some doubt that I have identified the species under consideration as a probable juvenile of *Abralia astrosticta* Berry, an Hawaiian species, the adult of which it very closely approaches. This course seems wiser than to propose a new species for an immature form practically on geographical reasons, since it exhibits no outstanding characters to distinguish it from those of *astrosticta.* Should adult specimens appear at a later date, a new specific name may be necessary or it may prove to be more allied to one or other of the recorded Japanese species.

Berry (1913 (1914), p. 145) records a new species as *Abralia astrolineata* from the Kermadecs, which, he points out, shows a condition intermediate between *Abralia* and *Abraliopsis* on account of a series of minute, heavily pigmented photophores on the ventral arms, characteristic of the latter genus. On account of this and the extensive banded arrangements of the photophores on the ventral surface of the mantle, the possibility of it being an immature form of *astrolineata* Berry is discarded.

The possibility of our species being juvenile of *Enoploteuthis galaxias* Berry (1918, pp. 211–221) is also discountenanced on general differences, and in particular on the extent to which the tail extends beyond the fins in *galaxias*, a character usually consistent in young forms of any species possessing such, but not present in our species.

Among the Enoploteuthidae in the *Warreen* collection were some very attractive larval forms with most conspicuous eye photophores. These appeared to resemble in detail *Asthenoteuthion planctonicum* Pfeffer (1912, pp. 172–3), a genus and species created by Pfeffer for a larval form from the North Atlantic. Pfeffer draws attention to its similarity to the genus *Lycoteuthis* Pfeffer, but points out that the gladius is definitely that of Enoploteuthidae, not Lycoteuthidae. Thiele (1934, p. 962), in referring to some larval forms of *Abraliopsis* Joubin, is uncertain to which genus of Enoploteuthidae *Asthenoteuthion* belongs. I think after careful examination of the Australian specimens, that these (Australian) may be smaller larval forms of the species I have tentatively designated *Abralia astrosticta* Berry. For reference, figures of one of these are given (figs. 5–10).

Localities from which they were obtained are as follows: Station 27/40. 21/4/40. N.200. Hor. (near Smoky Cape, North Coast, N.S.Wales), 31°08′, 153°05′. Shallow. One specimen (figs. 5–6, 8, 10).

Measurements.—Mantle, 5 mm. long, 2 mm. broad. Head, 2 mm. long, 2·5 mm. broad. Arms, 2nd pair (longest) 3 mm. Tentacular arms, 5 mm. Fins, 4·5 mm. across, 1·75 mm. long.—Station 57/38. 29/9/38. N.70. Hor. D.100–15 mm. (near North Head, Sydney, N.S.W.). Slope. A very immature specimen, mantle measurement only 3 mm.—Station 26/40. 20/4/40. N.200. Hor. 32°43′S., 152°55′ (near Seal Rocks, North Coast, N.S.W.). Slope. A minute, mutilated specimen (figs. 7, 9).—Station 106/38. 17/12/38. N.200. Hor. Two specimens, mantle lengths 4 mm. and 5 mm. respectively. 33°30′S., 152°21′E. (near Norah Heads, N.S.W.).—Station 39/38. 7/9/38. 28°S., 133°3′E. (near Danger Pt., North Coast, N.S.W.). Shallow. One specimen, mantle length 4 mm.

Genus Abraliopsis Joubin, 1896.

Abraliopsis Joubin (1896, pp. 19–35). Type, *Abraliopsis* (*Enoploteuthis*) *hoylei* Pfeffer, 1884 (designation), Mascarene Islands.

Animal like *Abralia* with large fins reaching to tail point. Extremities of ventral arms (4th pair) with a conspicuous series of heavily pigmented black bead-like photo-

phores. A single series of five large photophores occur on the ventral periphery of the eyeball.

Distribution.—Indian and Pacific Oceans. First record of the genus from Australian waters.

Abraliopsis ?hoylei Pfeffer.

(Plate xxiv, figs. 11–17.)

Enoploteuthis hoylei Pfeffer (1884, p. 17).

Animal small solid, and well developed. *Mantle*, rounded, gradually sloping from about half-way down to a conical point, raised to fairly sharp point mid-dorsally and on either side of the funnel ventrally, with slight emargination between. *Fins* large, cordate, just more than half the total length of the mantle; united, forming a rounded point posteriorly, and attached to mantle well in towards mid-dorsal line. *Head* large, slightly longer than broad, narrower towards its junction with mantle. *Eyes* large, globular, set high up, wide apart. *Arms* long and graceful, order 3, 2, 4, 1 (3 and 2 close). About twelve crowded very small *suckers* towards the distal part of arms, replaced for the remainder of their length by alternating rows of closely packed fleshy *hooks* along the inner sides of the arms, bounded on the outer side for about half the length by a wavy fold consisting of fleshy ridges running from a centre furrow to the edge; the arrangement developed strongly in second and third pairs of arms, to a lesser degree in the first (dorsal) pair, and absent on the ventral arms. The ridge-like knobs possibly develop into a second row of hooks as characteristic of the genus (see fig. 14). Hooks on ventral arms are scattered and immature. They cease on all arms a short distance before base. *Tentacular arms* without enlarged *clubs*, the areas simply being a hook- and sucker-covered portion embracing about one-fourth of the whole length of exposed tentacle, thinning out towards the tip of the tentacles. About 14 rows (four in a row) of closely packed, small suckers from tip to a little way down the club followed by four very large spines along one side with small scattered suckers along the other side, and a few rows of suckers only in oblique rows of two (fig. 13).

Funnel large and wide, not reaching much beyond lower level of eyes. *Interlocking system* as in genus. Buccal membrane 8-pointed, pustulose within. Gladius typical of family.

Colour.—Creamy-buff, with some irregular, very dark brown chromatophores scattered over mantle, head and arms in more or less regular pattern. About 14 very dark chromatophores occur along the backs of the tentacular clubs with larger, more widely spaced ones along the stalks. There are regular rows of photophores round the eyes, on the ventral surface of the head, in approximately two rows up the backs of the arms, and on the ventral mantle surface. A few larger photophores, possibly five, are on the ventral surface of each eyeball. The photophores throughout are conspicuous and on the mantle appear to run in about 6 longitudinal rows with a suggestion of some minute ones between them.

Measurements.—Mantle, 10 mm. long, 4 mm. broad. Fins, 5 mm. long, 7·5 mm. full width. Head, 4 mm. base of arms to mantle edge, 3 mm. broad. Dorsal arms 6 mm., 2nd arms 7 mm., 3rd arms, 7–7·5 mm., 4th arms 6·5 mm. Tentacular arms, 12 mm. long, 1 mm. broad.

Locality.—Station 66/38. 12/11/38. N.200. Hor. 35°07′S., 150°51′E. (near Jervis Bay, S. Coast, N.S.W.). Shallow. One specimen (figs. 11–14).—Station 217/39. 6/9/39. Obl. N.100. D.200. 24 miles east of Port Hacking, nr. Sydney, N.S.W. Slope. A slightly smaller specimen (figs. 15–17).—Station 223/39. 2/10/39. N.70. Obl. D.200. 34°05′S., 151°36′E. (Port Hacking). Slope. One very small immature specimen.—Station 145/39. 31/5/39. N.200. Hor. 36°15′S., 150°16′E. (near Montague Is., S. Coast, N.S.W.). Shallow. One small specimen.—Station 31/40. 25/4/40. (24 miles E. of Sydney Heads). Slope. Seven specimens (probably *A. hoylei*), 7 mm. long.—Station 60/38. 12/10/38. 43°13′S., 148°37′E. Slope. One specimen (near Port Arthur, Tasmania).

Remarks.—Like *Abralia*, the genus *Abraliopsis* has not been recorded from the Australian coast, the nearest habitat being the Kermadecs, where Berry (1913 (1914),

p. 148; 1916, p. 58) records an immature species which he refers with considerable uncertainty to *Abraliopsis hoylei* (Pfeffer, 1884). From the material on hand, it seems that the Australian specimens are immature forms of Berry's Kermadec species, but whether they are correctly regarded as *Abraliopsis hoylei* is uncertain until more material is available. In the meantime, I have followed Berry in classifying them as *hoylei*, rather than institute a new name for immature specimens. It is possible that a relationship may later be found to exist between the species and the common Japanese species *Watsenia scintillans* Berry (1911, p. 93).

Subfamily Pyroteuthinae.

Genus Pterygioteuthis Fischer, 1895.

Pterygioteuthis Fischer, 1895, p. 205. Type, *Pterygioteuthis giardi* Fischer, Morocco.

Characters of the subfamily. A genus created for *giardi* by Fischer.

Pterygioteuthis giardi Fischer, 1895.

((Plate xxiv, figs. 18–20.)

Pterygioteuthis giardi Fischer, 1895, p. 205.

Animal small, smooth, with narrow elongated *mantle* sloping sharply to a tail point. *Mantle margin* raised mid-dorsally, slightly raised ventrally each side of siphon at interlocking points, with rather deep emargination between. *Fins* fairly large, rounded, separated, much narrower at their point of attachment to mantle; situated well up mantle from tail tip, approximately their width away. *Head* large, rounded, slightly wider than mantle, dorsal surface flattish. *Eyes* large, globular, occupying main portion of ventral head area.

Arms irregular, strong, long and flattish, order 3, 2, 1, 4 (a smaller specimen from Station 132/39, 5/5/39, has order 2, 3, 1, 4). Very conspicuous, wide, fin-like membranes along ventral sides of the 1st, 2nd, and 3rd pairs of arms in particular, and only very slight suggestion on the ventral pair. Fin-like appearance due to parallel fleshy *trabeculae* extending from beyond edge of membrane to arm, which in specimen described appear to have become separated. The trabeculae diminish in length as they approach the arm tips. Ventral arms much more slender than remainder. Two rows of small, delicate *suckers* occur along the sessile arms, but no hooks are apparent, due no doubt to immaturity. There is only a slight indication of suckers on the ventral arms. *Tentacular arms* fairly stout, not very long, reaching about twice the length of the shortest arms. Constricted at their base, beyond which state they swell, constrict again, then taper gradually to a short unexpanded *club*. Fine fleshy circular cords attached to the second swelling of each *tentacular stalk* meet together under the base of the 3rd pair of arms. Minute suckers are arranged in rows of four on the club, finishing with a row of 3, 2, and 1 suckers respectively

Funnel wide at base reaching to lower level of eyeball, hooded, with small *valve* within. Interlocking system as in family. *Olfactory organ* as small pustule under each eye, slightly towards funnel. *Gladius* consists of a narrow rachis with sharply widened wings each side, which curl towards their point round the fleshy tail of the animal, and enclose it. *Buccal membrane* extensive, attached to inner surface of all arms, to a lesser degree with ventral arms.

A number of prominent *photophores* are present round the eyes, but the exact number is difficult to determine through the integument. They seem similar in distribution to those on the illustrations of *P. giardi*, that is, about five large main ones in a more or less regular row along the ventral surface of each eye, one or two at the base of each eyeball, and a number of others scattered over the eyeball. The small size and delicate nature of the specimen prevented too close an examination of these. Located within the mantle are *siphonal*, *branchial* and *abdominal* photophores, as characteristic of *giardi*. The siphonal organs are paired and lie below the base of the siphon; the branchial organs are also paired, one situated at the base of each gill, but only a suggestion of abdominal photophores can be noted, due no doubt to immaturity

and to the photophores being imbedded in the tissues. Hoyle (1904, pp. 39–43, 51–58) gives an excellent description, in particular of the luminous organs, of specimens of *P. giardi* dredged by the *Albatross* off the west coast of Central America.

Colour.—Buff, head much darker round eyes. Photophores dark. A suggestion of dark chromatophores scattered over ventral surface of body.

Measurements.—Mantle to tail tip, 7 mm. long, 2 mm. broad. Head, almost 3 mm. broad, 2 mm. long. Dorsal arms (1st pair), 2 mm. long; 2nd pair 2·5 mm., 3rd pair 3 mm., 4th pair (ventral) approximately 2 mm. Fins, 2 mm. long. Tentacular arms, 5 mm. long.

Locality.—Station 140/39. 29/5/39. N.100. Hor. D.0. Slope (24 miles east of Sydney Heads). One specimen, figured.—Station 210/39. 23/8/39. N.200. Hor. 35°07′S., 150°51′E. (near Wreck Bay, S. Coast, N.S.W.). Shallow. One specimen.—Station 132/39. 5/5/39. 30°15′S., 153°35′E. (near Coffs Harbour, N.S.W.). Slope. One specimen 6 mm. total length.

Remarks.—The fin-like membranes on the arms of this interesting little larval animal give the species on first acquaintance a resemblance to *Thysanoteuthis rhombus* Troschel, with which, of course, it has no relationship. Berry (1913, p. 566) describes a new species, *Pterygioteuthis microlampus*, from Hawaiian Islands, differing from *P. giardi* mainly in the *photophores* round the eyeballs and the nature of suckers and hooks on the arms. Since our species compares more favourably with Fischer's original figures and those of Chun (1910, Taf xii–xvi) and others; and as Massy (1916, p. 164–5) records *Pterygioteuthis giardi* from the summit of Great King, and off Three Kings Island, bringing the species into the South-West Pacific, it can be assumed that the species under consideration is a larval form of *giardi.* The species has been recorded from North and South Atlantic, North and South Pacific, and the Indian Ocean.

A few minute specimens (4–6 mm. length) of possible Enoploteuthidae came from the following stations, but are too immature for identification:

Station 136/39. 14/5/39 (near Cape Moreton, Queensland). Shallow. Two specimens.—Station 219/39. 15/9/39 (S. of Cape Byron, N.S.W.). One specimen.—Station 27/40. 21/4/40 (near Smoky Cape, N.S.W.). One specimen.—Station 131/39. 5/5/39 (near Coffs Harbour, N.S.W.). One specimen.—Station 125/39. 2/5/39 (Long Bay, near Sydney, N.S.W.). One specimen.

Family Onychoteuthidae.

Animals of moderate or large size, muscular, firm. Body elongate, attenuated posteriorly; nuchal fold sometimes present. Fins terminal, sagittate. Arms with biserial suckers only, no hooks. Tentacular arms in young armed with quadriserial suckers, the inner row of which in the adult usually undergo a change into hooks, and the outer two rows disappear. Gladius slender, its posterior portion expanded into a spoon-shaped lanceola with end cone and cartilaginous spine. Buccal membrane seven- rarely eight-pointed.

Pfeffer in 1912 introduced the subfamily Onychoteuthinae which, however, Thiele does not use. Distribution—all seas.

Genus Onychoteuthis Lichenstein, 1818.

Onychoteuthis Lichenstein (1818, p. 1591).

Characters of the family. Nuchal fold present. Biserial hooks only on adult tentacular clubs. Photophores have been observed within mantle cavity. Genotype, *O. bergii* Lich., 1818 = *O. banksii* Leach, 1817.

Onychoteuthis ?rutilus Gould, 1852.

(Plate xxv, figs. 6–11.)

Onychoteuthis rutilus Gould (1852, p. 482). Near Sydney, N.S.W.

Three minute specimens, only a few millimetres in total length. The *mantle* is arched mid-dorsally, sloping posteriorly to a sharp point through which the sharp spine of the *gladius* protrudes, seen as a dark streak along the back. The gladius is flexible and seems adaptable to the bent shape assumed by the larvae. The *head* has sunk down

into the mantle in two specimens. *Eyes* and *funnel* large; *arms* fairly long, 3rd pair the longest. *Suckers* arranged in two rows on arms, 2–4 rows on *tentacle clubs*. No *photophores* observed within mantle cavity.

Colour.—General colour dark buff.

Measurements.—Total length from tail tip to end of tentacles, 7 mm.

Locality.—Station 127/39. 3/5/39. N.100. Hor. 33°18′S., 152°22′E. (near Norah Head, N.S.W.). Slope. Two minute specimens (figured). Few millimetres in length.—Station 198/39. 16/7/39. N.70. Obl. 28°47′S., 153°56′E. (near Cape Byron, N.S.W.). shallow. One minute specimen.—Station 39/40. 6/5/40. N.200. Hor. 39°20′S., 148°50′E. (north of Babel Is., Bass Strait). Slope. One specimen 5 mm. total length.

Remarks.—There is a very close similarity between the illustrations of larval forms of *Onychoteuthis banksi* Leach, 1817, as given by Pfeffer (1912, t. 3, f. 13–25; t. 6, f. 1–15) and our specimens. Although the larval form of *O. rutilus* is not known, I am associating these specimens with this species, rather than *banksi* owing to the close proximity of their stations to the type locality of *rutilus*. *O. rutilus* is said to differ from *banksi* in proportions and colouring, but in such larval forms it is not expected that difference in proportions would be apparent, and no deduction can be made from their colouring.

As *O. banksi* has an almost universal distribution, and has been already recorded from New Zealand and South Australia, its range is quite likely to extend into N.S.Wales. Whether *rutilus* will remain a distinct species, or prove eventually to be only a local form of *banksi* remains to be seen.

An interesting specimen from 60/38. 12/10/38. 43°13′S., 148°17′E. (near Port Arthur, S.E. Tasmania). Slope. (Mantle, 15 mm. × 6 mm., mantle edge to tip of second arm, 7 mm., width across fins, 9 mm., depth 5 mm.) is undoubtedly a young Onychoteuthid, and for the present may be regarded as possibly an immature form of *rutilus* (fig. 9).

A strong feature of this specimen is the surface sculpture of the mantle, which consists of numerous longitudinal ridges running parallel for their greater length, but here and there uniting (fig. 10). They are very defined to almost the middle of the fins. There is also a suggestion of transverse parallel lines. The minute specimen from Station 39/40 (above) shows similar fine ridging. I have examined specimens in our collection marked *O. banksii* Leach (North Pacific) and *O. rutilus* Gould (N.S.W.), and find the same longitudinal lines present; but even more pronounced, especially on the ventral surface of the fins, are transverse lines. Sasaki (1929, p. 230) in a description of *Moroteuthis robusta* (Dall) Verrill, from Japanese localities, points out the peculiarity of this same sculpture in his species, which is indicated in his illustration (p. 231, f. 171). The parallel-lined sculpture noted by Sasaki, however, does not seem to fall in with the pustulose sculpture characteristic of the genus *Moroteuthis*.

From a comparison of the small species from Station 60/38, and the following species from Station 17/38, which are approximately the same size, it will be seen that parallel lines and pustules as surface sculpture provide strong distinguishing characters amongst various forms of Onychoteuthidae.

Genus Tetronychoteuthis Pfeffer (1899), 1900.

Tetronychoteuthis Pfeffer (1899, pp. 155, 161). Type, *T. dussumieri* (Orbigny), 1839. Mauritius.

Members of the family Onychoteuthidae in which the adults have four rows of hooks on the main portion of the club; suckers on the arms are rudimentary, and the mantle integument has the appearance of very tubular shagreen.

Tetronychoteuthis ?massyae Pfeffer, 1912.

(Plate xxv, figs. 1–5.)

Tetronychoteuthis massyae Pfeffer (1912, pp. 102–4), North Atlantic.

Animal small, typical Onychoteuthid in shape. *Mantle* wide anteriorly, faintly sloping towards fins where there is a slight bulge, then sudden slope to sharp tail-point.

Mantle margin has a rather pronounced nuchal point, with a straight margin ventrally, except for sharp point at each interlocking ridge. *Fins* conspicuous, almost rectangular, wider than long, set well in towards centre anteriorly, almost touching at tail-point.

Head fairly long, eyes set well up with deep sinus anteriorly, and eyeball occupying large area ventrally. *Funnel* very broad at base, not reaching further than the level of the base of the eyeballs; hooded, valved within a deep furrow and then a bulge below the open. Funnel cartilage grooves simple, fairly deep and corresponding mantle ridge narrowly linear. *Funnel groove* very deep, but not fully developed, funnel attached by two bands dorsally uniting within the groove; and each showing a slight splitting into two at their point of attachment to funnel.

Arms long, rounded, sloping from fairly wide base to narrow curling tip, order 2, 3, 1, 4, but except second pair, are almost level. *Suckers* rather small, bowl-shaped, stalked, arranged in two crowded oblique rows to base of arms. There is a slight suggestion of a wing along the outer edge of the third arms. *Tentacles* almost twice as thick and long as arms, almost rectangular in shape, with furrow down inner centre. *Club* consists of almost half-exposed portion and is a slightly expanded area with a slight wing on the upper portion. *Suckers* fairly small, crowded, long stalked, mostly in four rows, but in some places appear to be in rows of six, but this may be due to crowding. Slightly down the club, they separate into two closely-set rows on either side of the club, with a median groove between them and gradually dwindle away as they approach the stalk of the tentacle. There is no sign of hooks on either tentacle. The suckers are easily removed from the club. Numerous minute tubercles can be seen jutting from the edge of the ring of the suckers and, as far as can be distinguished, are present also, in a lesser degree, on the inner edge of the ring.

There are about 3–4 longitudinal folds on each olfactory crest. Buccal membrane is seven-pointed.

The most distinguishing feature about this small cephalopod is the surface structure of the mantle, which consists of irregular, divaricating rows of very closely set rounded pustules, like the sculpture on certain dorid nudibranchs, giving the mantle integument the appearance of tubercular shagreen. The structure is mainly confined to the mantle and fins, only faintly appearing on the head. Magnified, each pustule, appears rosette-shaped on a short, stumpy stalk, its edge with about six or more rounded points and the centre of the pustule rounded and slightly elevated (fig. 5).

Colour.—Uniform dull liverish-yellow, with suggestion of dark brown small patches scattered over body and backs of arms.

Measurements.—Length of mantle, 17 mm., breadth, 5mm. Fins, 5 mm. long, 6 mm. broad. Head, mantle margin to base of arms 5 mm., breadth across eyes, approximately, 5 mm. Tentacles, 13 mm. 2nd arm, 10 mm., 1st arm, 6 mm.

Locality.—Station 17/38. 18/10/38. 42°40′S., 148°16′E. (near Maria Island, S.E. Tasmania). Shallow. One specimen.

Remarks.—The rosette-shaped tubercles on the integument of the specimen allies it more with *Tetronychoteuthis massyae* Pfeffer than *T. dussumierii* Orbigny, 1839, the other species of the genus. The tubercles of *T. massyae* as shown in Pfeffer's illustration (1912, Taf. 14, f. 19) exhibit the same rosette shape with short stalk as in ours, whereas, in his illustration of those on *dussumierii*, they seem totally different in appearance and their margins are entire. The type of *massyae* is almost twice the size of our specimen, having a mantle length 30 mm., but is nevertheless a young specimen and, although it shows sufficient differences to regard it as separate from the adult *T. dussumierii*, Pfeffer admits it may probably prove to be a juvenile of *dussumierii*, in which event our specimen would most likely prove the same. Little can be done to substantiate this probability of Pfeffer, however, until more material is available to work upon.

Massy (1916, p. 165) records a species, *Moroteuthis* (*Moroteuthopsis*) *ingens* (E. A. Smith), from off Three Kings Island, New Zealand, with a mantle length of 20 mm. Although this is practically same size as our specimen, it has one hook in the centre of

the tentacular club, and what appear to be sockets of many others in the median part of the club, disagreeing with the former specimen. Massy does not mention the structure of her species, nor does she give a full description, so it is difficult to judge whether it is the same as the Tasmanian species. In any event, the latter species seems better placed in the genus *Tetronychoteuthis* than in *Moroteuthis* which seems to have different sculpture again.

Beyond Massy's recorded *M. ingens*, the Tasmanian species is the only other record of a tuberculated form of *Onychoteuthidae* from the South-West Pacific.

Family Ctenopterygidae, nov.

Animal small, rounded, firm, with head and mantle about same width. Mantle slopes posteriorly to a rounded tail. Head short, arms fairly long, almost equal, pointed at extremities, ventral pair very broad at base. Head and arms together about equal half length of mantle. Tentacles fairly long, slender, clubs not markedly expanded. Suckers minute, in more than two rows at extremities on arms, and more than four rows on tentacle clubs. Eyes large, globular. Olfactory papillae elongate. Fins conspicuous, lateral, extending more than half-way up mantle sides, comb-like, separated into fleshy parallel filaments attached to mantle at the base by a fleshy membrane. Funnel large, reaching almost to base of ventral arms, slightly hooded, valve within, attached to head by pair of dorsal bridles. Interlocking system consists of simple elongated groove widened at base, and a long thin ridge.

The genus *Ctenopteryx* Appellof (1889), 1890, for which I here propose the family name Ctenopterygidae, is so distinct that I cannot see clearly the reason for its inclusion by Pfeffer (1900, p. 171) in the family Bathyteuthidae, since there seems little relationship between it and the genus *Bathyteuthis* Hoyle. Grimpe (1922), in establishing the subfamily Ctenopteryginae for *Ctenopteryx*, apparently recognized their differences as more than generic, but Thiele does not include this subfamily in his handbook.

The comb-like fins extending along the greater part of the mantle, equal width of head and mantle, the greater length of the latter in comparison with that of the former, and other characters, are so unlike features of *Bathyteuthis* as described by Hoyle (1886, p. 167) that its removal altogether from the family Bathyteuthidae seems warranted. The arrangements of the suckers on arms and tentacles seem one of the few characters the two genera have in common. The fins of *Bathyteuthis* are described by Hoyle as "subterminal, small and separated", and in his description of *B. abyssicola* (1886, p. 168), as "separate", meaning apparently that they do not meet or unite at their points of attachment to the mantle. In placing *Ctenopteryx* in the family Bathyteuthidae, Pfeffer may have misunderstood "separate" as meaning an individual fin was separated, i.e. into filaments.

As Hoyle points out, Verrill remarks on the marked embryonic or primitive characters displayed by his genus *Benthoteuthis* Verrill (1885, p. 401)—since proved synonymous with *Bathyteuthis*—which are not characteristic of *Ctenopteryx*. On general appearances alone, and in their comparative proportions, the two genera seem quite distant.

Genus Ctenopteryx Appellof (1889), 1890.

Ctenopteryx Appellof (1889), 1890, p. 3. Type, *Ctenopteryx sicula* Ruppell (Verany).

A genus created by Appellof for a small cephalopod 15 mm. long, from Messina, *Ctenopteryx fimbriatus* Appellof. Ashworth and Hoyle ((1905) 1906, pp. 1–7), in a review of this genus, regard *Ctenopteryx cyprinoides* Joubin (1894) from Corsica as a synonym of *C. fimbriatus*, likewise *Ctenopteryx* (*Calliteuthis*) *nevroptera* Jatta, 1896, as a possible synonym, and *Sepioteuthis sicula* Ruppell (Verany), 1851, as a doubtful form, although admitting it had been considered identical with *fimbriatus*. Pfeffer, however (1912, pp. 337–339), makes *cyprinoides*, *fimbriatus*, *and nevroptera* all synonyms of *Ctenopteryx* (*Sepioteuthis*) *sicula* Ruppell (Verany), which becomes the type of the genus. This classification is maintained by Thiele (1934, p. 471).

Characters of the genus are those of the family, the extraordinary comb-like fins immediately distinguishing it from other genera. Suckers are minute, arranged on the arms in probably four rows towards the upper parts and in two rows lower down (two rows throughout length of ventral arms, in specimen described below). Suckers on tentacular clubs very small, in about six rows.

The distribution of the genus so far has been confined to the Mediterranean and Atlantic. The specimen described below provides the first record of the genus from the South-west Pacific.

Ctenopteryx sicula Ruppell (Verany).

(Plate xxv, figs. 16, 17.)

Sepioteuthis sicula Ruppell (Verany, 1851, p. 51).

Animal small, plump, rounded. *Mantle* oblong, gradually tapering to rounded tail. *Mantle edge* slightly pointed mid-dorsally, and ventrally at position of interlocking ridge. *Head* short, as wide as mantle. *Eyes* large globular, shiny gold in appearance. *Olfactory* pustule elongated; a suggestion of a few small pustules round eye area on ventral surface.

Fins comb-like, conspicuous, consisting of about 24 long, narrow, fleshy filaments extending from the tail to about half-way up each side of the mantle, to which they are attached by means of a narrow fleshy strip running the length of the fin. Their greatest width is reached at about the 8th or 9th filament from the posterior end, after which they diminish in width as they proceed up the mantle sides. The filaments are free from their base, as figured by Appellof ((1889) 1890, fig. 1) in his description of *Ctenopteryx fimbriatus*, differing slightly from those in *Ctenopteryx sicula*, as figured by Pfeffer (1912, T. 27, f. 16–23), which appear to have membrane between them, as in fish fins. As there is a suggestion of inter-membrane between some filaments on the *Warreen* specimen, it is possible it tears easily.

Arms fairly long, tapering towards tip, ventral pair very broad at base forming a fold round the *tentacular arms*; order 4, 3, 2, 1, but 2nd and 3rd arms almost equal. *Suckers* on arms in four rows, replaced by two rows towards the base. *Tentacles* long, narrow; *clubs* not markedly expanded. *Funnel* stout, reaching almost to base of ventral arms; slightly hooded, valved within, attached to head by two fleshy bands well down at base of funnel. *Interlocking system* consists of a long simple groove, widened at base, and corresponding long, thin ridges on ventral mantle. A dark streak along dorsal surface indicates the *gladius*, which was not removed owing to the rarity of the specimen.

Colour.—Uniform dark buff; mantle with minute speckling of darker colour over surface and arms.

Measurements.—Mantle margin to tail tip, length 11 mm., breadth 5 mm. Head, 2 mm. long, 5 mm. broad. Largest filament of fin, 3 mm. long. Arm, ventral, 5 mm. long, 2 mm. broad at base. Other arms slightly smaller, about 4·5 mm. long, 1 mm. broad. Tentacular arms, 7 mm. long, 1 mm. broad.

Locality.—Station 266/39. 1/11/39. 36°17′S., 150°25′E. (near Montague Is., N.S.W.), N. 100. Slope. One specimen.

Remarks.—This fascinating little species, appearing in waters so far removed from its known habitat, the Mediterranean regions, provides one of the most interesting and important additions to the Pacific cephalopod fauna. Our specimen exhibits no characters to determine it other than *Ctenopteryx sicula*; and since little is yet known of planktonic cephalopods in the South Pacific, it may be that the range of this species will be found later to extend over a much greater area than previously known, as in the case of the extremely graceful *Brachioteuthis riisei* (Steenstrup), which by degrees is being found to have an almost universal dispersion.

Family Brachioteuthidae.

A family represented to date by only a single genus.

Body slender, loligoform, fins rhomboid. Arms with two rows of small, rounded suckers. Tentacular arms very broad, pointed distally; suckers in four or more rows extending well down their length. Siphonal interlocking system simple and linear. Gladius slender, consisting for the most part of little but the rachis, terminating in a long pointed cone, the broader, lanceolate posterior sides infolded. *Distribution* almost universal.

Genus Brachioteuthis Verrill, 1881.

Brachioteuthis Verrill, 1881, p. 405. Type, *Brachioteuthis beanii* Verrill (designation). New England region.

Tracheloteuthis Steenstrup, 1881 (1882), pp. 293–4. Type, *Tracheloteuthis riisei* Steenst. (des. Hoyle, 1905).

Characters of the family. Funnel has internal valve and dorsal bridle. *Gladius* simple, linear for some length, suddenly branching into a much broader posterior portion, sides of which fold inwards. Second pair of arms longer than others.

Both Pfeffer and Hoyle (Hoyle, 1904, pp. 14, 20) independently came to the conclusion that the genera *Brachioteuthis* Verrill and *Tracheloteuthis* Steenstrup were identical. Thiele (1934, p. 971) maintains *Tracheloteuthis* as a synonym, and follows Pfeffer (1912, p. 345) in using the family name Brachioteuthidae.

Brachioteuthis riisei (Steenstrup).

(Plates xxvi, figs. 15–17; xxvii, fig. 25.)

Tracheloteuthis riisei, Steenstrup, 1881, p. 294.

Animal very small, *body* cylindrical, slightly bell-shaped anteriorly. *Head* squarish, much narrower than *mantle*, from which it stands out by means of a well developed "neck". *Eyes* well developed, set fairly high up in head. *Mantle margin* almost straight across, rising dorsally to a slight peak in the nuchal region, but with a more pronounced peak on each side of the ventral margin, indicating the mantle cartilages of the interlocking system. About half-way down its length, the mantle tapers towards a sharp tail point.

Fins small, rather longer than broad, with rounded edges. *Arms* fairly short, order 2, 3, 4, 1; second pair, almost twice length of the others. *Suckers* cup-shaped, slightly stalked, biserial. *Tentacular* arms stout, more or less uniform width throughout, except at tips; *tentacular club* not distinct. Stalked suckers present for about three-quarters of the way down, confined to a few minute ones on the extreme tip, followed by about 8 irregular rows containing 6–8 suckers in a row, then a few rows of four, gradually diminishing into two in a row. *Funnel* small, does not protrude to any extent beyond mantle; simple linear interlocking cartilaginous groove on either side.

Colour.—Creamy-white, without colour markings on the mantle or fins. Head appears darker than mantle, due to dark red-brown bands round eyes and a dark spot over each eye, more conspicuous on ventral surface. A dark brown line runs from beneath each eye on the ventral surface in towards the centre where they meet to form a single line extending down to behind the funnel.

Measurements.—Mantle margin to tail, 13 mm., breadth 5 mm. Fin, approximately 2 mm. × 2 mm. Head, mantle margin to base of arms, 4 mm. long, 3 mm. broad. Arms, 2nd pair 2 mm. long, others correspondingly shorter. Tentacular arms, 5 mm. long, 1 mm. broad. Total length from tentacular arm tip to tail, 21 mm. (approx.).

Locality.—Station 255/39. 25/10/39 (24 miles east Port Hacking, N.S.Wales). Slope. One specimen (figured). Specimens from other Stations as follows:

Station 224/39. 4/10/39. N.70. Hor. D-0. 15 mm. 35°12′S., 150°40′E. (near Wreck Bay, south coast, N.S.W.). Shallow. One specimen. Length, mantle to tail 3 mm., breadth 2 mm. (Fig. 25).—Station 217/39. 6/9/39. N.70. Hor. D-0. 15 mm. (24 miles east of Port Hacking). Slope. One specimen, 5 mm. long (mantle to tail), 3 mm. broad.—Station 137/39. 16/5/39. N.70. D-25. Hor. 30°55′S. 153°08′E. (near Smoky

Cape, north coast, N.S.W.). Shallow. One specimen 3 mm. × 2 mm.—Station 187/39. 12/6/39. Hor. N.200. 41°14′S., 148°40′E. (near St. Helens, N.E. Tasmania). This specimen is slightly larger than that figured, its total length being approximately 27 mm.—Station 302/39. 15/11/39. N.100. Obl. (N.E. of Gabo Is.). One specimen.

Remarks.—This species is a small semi-transparent, gelatinous animal. Its mantle is capable of becoming very inflated, causing the margin to stand out widely round the narrow head.

Berry (1912, pp. 336–8), in recording its occurrence in the Hawaiian Islands, remarks that *Brachioteuthis riisei* is a species of almost cosmopolitan distribution, and substantiates this with a list of its recorded localities at that time, embracing the Mediterranean, Pacific, Indian, and Indo-Pacific regions. The presence of this species in Australian waters, therefore, is of considerable interest, permitting the family to be recorded for the first time from the South-west Pacific.

Nothing about the specimens examined, which show little or no variation from one another, suggests that they are other than *Brachioteuthis riisei*. That the species should be found so far south as Tasmania, adds still further to its interest.

Family Ommastrephidae.

Animals of moderate or considerable size. Loliginiform, fins sagittate, subterminal. Suckers in two rows on arms, four rows on tentacular clubs; none of the suckers modified into hooks. Funnel groove well-defined, open, forming foveola or other folds at anterior part. Funnel adductors *bipaired*, one pair submedian, the other lateral in position. Funnel cartilages highly developed and complex, the groove an inverted T-shape. Buccal membrane with seven projecting ribs. Gladius consisting of little but the rachis throughout its length, terminating in a deep hollow cone.

Subfamily Ommastrephinae.

Main characters of family. Foveola in funnel groove often showing longitudinal folds internally, but invariably devoid of pocket-like folds.

Genus Nototodarus Pfeffer.

Nototodarus Pfeffer, 1912, p. 223. Genotype, *Ommastrephes insignis* Gould, New Zealand.

Characters of family. Body large, subcylindrical, gradually narrowing to point behind. Fins transversely rhomboidal, about one-third length of body in adult. Arms rather long, order 2, 3, 4, 1, but nearly equal. Suckers in two compressed rows. Tentacular arms about one-third longer than arms; suckers fairly large, occupying a fair amount of club. 8–15 teeth on sucker rings. Gladius slender.

Nototodarus gouldi (McCoy).

(Plate xxvi, figs. 1–14.)

Ommastrephes gouldi McCoy, 1888, pp. 255–257. Type locality, Victorian coast.

Animal small, well developed. *Mantle* subcylindrical tapering to point behind. *Fins* squarely emarginate, fairly large, triangular. *Head* large, squarish, ridge along dorsal surface at mantle margin. *Eyes* situated well up head, with large indented sinus anteriorly. *Siphonal cartilaginous* grooves well developed, usual inverted T-shape, corresponding ridges on inner ventral mantle short, narrow anteriorly, widening into rounded portion posteriorly.

Funnel short, stout, attached to head by two sets of strong *adductors*. Internal *valve* present. *Funnel groove* has a shallow semicircular membraneous fold cutting off the apical portion of the groove. *Arms* moderate length, flattened; order 2, 3, 4, 1, second arm decidedly longer. Large cauldron-shaped *suckers* in two, regularly alternating rows. *Keels* well developed on outer angles of arms. *Tentacular arms* partly retracted, *clubs* not strongly differentiated; sucker-bearing portion comprising more than half the exposed length. Suckers in four rows. *Buccal membrane* seven-pointed.

Colour.—Creamy-buff; dorsal surface of head with rounded dark brown chromatophores; smaller ones extend in several rows up dorsal sides of arms and regularly

between each sucker on the inner surface of the arms. Similar chromatophores appear on mantle integument. There is a bronze sheen round each eye.

Measurements.—Mantle margin to tail tip, 23 mm. long, 8 mm. broad. Mantle margin to base of arms, 6 mm. Longest arm (2nd pair), 9 mm. Tentacular arm, 12 mm. Width across fins, 12 mm., depth 6 mm.

Locality.—Station 73/38. 25/11/38. 39°57′S., 148°35′E. (off Babel Is., Bass Strait). Slope. One specimen (fig.).—Station 39/40. 6/5/40. N.200. Hor. 39°20′S., 148°50′E. (north of Babel Is., Bass Strait). Slope. One minute specimen, only few millimetres total length.

Rhyncoteuthion larval form.—From 17 different stations off the coast were taken a number of most interesting cephalopod larvae of the family Ommastrephidae. This larval form is immediately recognized as, during a curious stage in its development, the two tentacular arms, instead of being free, are fused along a portion or the whole of their inner faces to form either an elongate proboscis-like organ or a pincer-shaped one. It has been found convenient in the past to give these curious little animals provisional consideration by themselves, since their development and relationships have been insufficiently known to refer them to the proper adult form.

No type has been given for the forms, but the generic name *Rhyncoteuthion* was applied to them by Pfeffer (1908, p. 88), and one species has been given a name, *Rhyncoteuthion chuni* Hoyle (1904, pp. 32–33). Chun (1910, p. 202) considered there were more than one species of Ommastrephidae amongst the 35 larvae of *Rhyncoteuthion* he had met from the Indian and Atlantic Oceans, one with a slender body and moderate eyes, the other with plump body and large eyes. Pfeffer (1912, p. 383), on the other hand, regards them more probably as one species; the fluctuating conditions of environment may account for their individual variation. Massy (1916, pp. 166–167), in describing species of *Rhyncoteuthion* from the west of the Canary Islands, and off North Island, New Zealand, thinks future material may prove Chun correct in surmising two forms exist.

Pfeffer (p. 383) arrived at the conclusion that both Chun's types are probably referable to *Sthenoteuthis bartrami* (Lesueur), which is of interest here since Berry (1914, p 148) recorded *S. bartrami* from the Kermadecs.

A close examination of more than thirty specimens, measuring from 2 to 13 mm., but mostly 2–5 mm., from the different stations off the east Australian coast, shows slight variations which appear due to their different stages of growth, and not to difference of species.

The specimens display typical *Rhyncoteuthion* characters—large eyes and few but conspicuous suckers; the ventral arms very much smaller than the remainder, and the 2nd pair longer. In all but two the tentacles are fused almost throughout their stalks, a furrow indicating their future line of separation. In the two specimens from Station 31/40. 25/4/40. N.70. Hor. (24 miles east of Sydney Heads, N.S.W.). Slope (figs. 3, 4, 5), one of which has a total length of 12 mm. and the other 16 mm., the tentacles show a marked separation from their base in fig. 3, and in fig. 5 have separated as far as the base of the club. These examples of separation are interesting in the light of Robson's findings (1931 (1932), p. 102) that the tubular structure formed by the fused tentacles, and known as "Rüssell" by German authors, continued in the fused stage until the squid is 8–10 mm. long; the tentacles then commence to come apart and assume normal form and position as the animal develops.

From a comparison of specimens (figs. 3, 4, 5), and that in Fig. 1, and then in turn with a number of specimens of different growth of *Nototodarus gouldi* removed from stomachs of Bluefin taken off our coast, I feel sure that the *Rhyncoteuthion* forms in this collection are none other than a larval stage in the development of *Nototodarus gouldi* McCoy, a cephalopod plentifully represented in New South Wales, Victoria, Bass Strait, Tasmania, and South Australia.

Other stations from which these larval forms were taken are enumerated below. It will be seen their localities are well within range of those favoured by *Nototodarus gouldi*.

Station 141/39. 7/9/39. N.70. Hor. D-0. 30 mm. (Port Hacking, N.S.W.). Slope. One specimen, total length 8 mm. (fig. 10).—Station 31/40. 25/4/40. N.200. Hor. (24 miles E. Sydney Heads, N.S.W.). Slope. Ten specimens, total length approximately 5–10 mm.—Station 106/38. 17/12/38. N.200. Hor. 33°30′S., 152°21′E. (near Broken Bay). Slope. One specimen.—Station 6/39. 7/1/39. N.70. Hor. D.25–30. 35°07′S., 150°31′E. (near Wreck Bay, South Coast, N.S.W.). Slope. One specimen, 2 mm. total length.—Station 24/40. 27/2/40. N.100 (24 miles E. Port Hacking, N.S.W.). Three specimens. Total length less than 7 mm. One specimen figured (fig. 8).—Station 134/39. 6/5/39. N.70. Hor. D-100. 28°36′S., 153°57′E. (near Cape Byron, North Coast, N.S.W.). One specimen, total length 3 mm. Slope (fig. 14).—Station 47/38. 20/9/38. N.70. Hor. 26°54′S., 153°24′E. (north of Cape Moreton, Q'land). Slope. One specimen, 2 mm. total length (fig. 12).—Station 30/40. 22/4/40. N.100. Hor. 30°18′S., 153°20′E. Slope (south of Coffs Harbour, N.S.W.). One specimen, 3 mm. total length.—Station 28/40. 21/4/40. N.200. Hor. 31°08′S., 153°20′E. (near Smoky Cape, N.S.W.). Slope. One specimen, mantle length 6 mm. (figs. 6, 7).—Station 129/39. 3/5/39. N.70. Hor. D-0. 32°34′S., 152°55′E. (near Seal Rocks, N.S.W.). Slope. One specimen, 2 mm. total length.—Station 30A/38. 29/9/38. No.200. Hor. D-25 (24 miles E. Port Hacking, N.S.W.). Slope. One specimen, total length 5 mm.—Station 40/38. 12/9/38. N.70. Hor. 26°54′S., 153°24′E. (north of Cape Moreton, Queensland). Shallow. One specimen, 5 mm. (fig. 9).—Station 104/38. 15/12/38. N.70. Hor. (24 miles E. Port Hacking). Slope. One specimen, 3 mm. length.—Station 132/39. 5/5/39. N.70. Hor. 30°15′S., 153°33′E. (south of Coffs Harbour). Slope. Three specimens, less than 3 mm. in length.—Station 193/39. 14/6/39. 37°05′S., 150°04′ E. (near Twofold Bay, South Coast, N.S.W.). Shallow. One specimen (fig. 11).—Station 141/39. 30/5/39. N.100. Hor. (Port Hacking). Shallow.—Station 24/40. 27/2/40. N.100–200 (24 miles E. Port Hacking, N.S.W.). Slope. Three specimens, 5 mm. (fig. 13).

Apart from Massy's record of *Rhyncoteuthion* larval cephalopod off North Island, New Zealand, the above specimens are the only other records of this extraordinary little creature in the South-West Pacific. In a comparatively small collection of planktonic cephalopods, which has nevertheless provided a surprising number of new records for these regions, this has proved to be one of the most interesting, since it can almost without doubt be regarded as a larval condition of a definite species of Ommastrephidae, *Nototodarus gouldi* (McCoy). Massy does not apply her larval species to any particular Ommastrephid, and Pfeffer (1912, p. 380), as stated above, regards the Atlantic and Indian Ocean species as probably referable to *Sthenoteuthis bartrami*.

Family Histioteuthidae.

Animals moderate sized, body short, barrel-shaped, mantle thick and fleshy, fins subterminal, medium sized. Arms and tentacles long and thick; suckers only, in two rows on sessile arms, four rows on tentacular clubs. Siphonal interlocking cartilages simple linear grooves and ridges. Photogenic organs well developed, plentifully distributed over the surface of mantle, head and arms. Some members have an extraordinarily enlarged left eye. Gladius simple, with broad wings. Distribution.—Atlantic; Mediterranean; Pacific. A family of few genera and species.

Genus Calliteuthis Verrill, 1880.

Calliteuthis Verrill, 1880 (1881*a*), p. 295.

Main characters of the family. Body short; fins rounded, united behind the posterior extremity of body. Funnel attached to head by two muscular bands. Arms long, free, without interbrachial membrane. Dorsal and lateral arms with one row of large and one row of small photophores; ventrolateral and ventral arms with three rows of luminous organs.

Two species of this interesting genus have been recorded from the South Pacific, an immature surface specimen by the "Challenger" off North New Zealand, and with considerable uncertainty designated *Calliteuthis reversa* Verrill 1880, and an adult species, *Calliteuthis miranda* Berry 1918, from 270 fathoms, S.E. × S. off Gabo Island, Victoria, by the "Endeavour". As the type locality of *C. reversa* is off New England, North Atlantic, and as the name has been applied doubtfully to the immature New Zealand specimen, it seems possible that the latter species may later be found more closely allied to the Australian *C. miranda* Berry.

Calliteuthis miranda Berry.

(Plate xxv, figs. 12–15.)

Calliteuthis miranda Berry, 1918, pp. 221–228. Type locality, 270 fathoms, S.E. × S. of Gabo Island, Victoria.

Animal very small, solid; body short conical, tapering to a sudden point posteriorly. *Fins* rounded, united behind. *Head* large, strongly asymmetrical. *Eyes* large, prominent, especially left one, which is extraordinarily large, being twice the size of the right eye and taking up the whole side of head. *Mantle margin* pointed mid-dorsally, slightly pointed ventrally with little emargination below the funnel. *Arms* stout, long, tapering to point anteriorly, about equal length, except dorsal and ventral pair. The dorsal pair are much smaller and more slender. *Suckers* large, hood-shaped, in two well-separated rows on all arms. *Tentacular arms* long, with a pronounced expanded *club* thinning out to a point. *Suckers* smaller than on arms, crowded, in about 6 rows for part of the club, then in rows of four; fixing apparatus extends down stalk for about one-fifth its distance. A fine muscular cord runs from the base of each tentacle into a separate pouch between the buccal membrane and the true tentacular pockets, similar to that described by Berry (p. 223, fig. 6). Gladius not examined.

Funnel short, broad, attached to head by pair of wide fleshy bands. A simple, conical *olfactory papilla* is below each eye. Many large *photophores* are scattered profusely over the mantle, head, and arms, and in a circle round the eyes. These are very pustulose in appearance, dark coloured, with a light spot in front.

Colour.—Deep buff-colour, with bronze-purple tinge over the whole surface, and rather large dark brown *chromatophores*. Eyes reddish-purple with very dark, broad band round the pupil. Along inside of arms are chocolate-coloured bands alternating with the suckers, running from the outer edge of arm to mid-line. The above colours refer to the preserved specimen.

Measurements.—Mantle to tail tip, 10 mm. long, 5 mm. broad. Head, 4 mm. long, 5 mm. broad. Fins, 5 mm. long, 8 mm. full width. Dorsal arms, 6 mm., 2nd arms, 7 mm., 3rd arms, 7 mm., 4th (ventral), 5–6 mm. Tentacles, 12 mm.

Locality.—Station 65/38. 11/11/38. N.200. Hor. (24 miles E. Port Hacking, N.S.W.). Slope. One specimen, good condition (figured). A much smaller, immature specimen [from Station 60/38. 12/10/38. N.200 (near Port Arthur, Tasmania). Slope (figs. 14, 15)] is the same species, although the left eye has not enlarged to any extent.

Remarks.—Though immature, there is no doubt the above specimens are young of *C. miranda* Berry, and thus extend the Australasian range of this extraordinary cephalopod. Berry has given a detailed description of his species, but the discovery of young forms from new localities, warrants the above rather full description.

Family Chiroteuthidae.

Body slender, spindle-shaped. Fins large, rounded or leaf-shaped; sometimes lateral flaps on an extension of the gladius give impression of second pair of fins. Arms fairly long but extraordinary length and breadth of ventral pair in comparison with others forms a marked character. Suckers in two rows. Tentacular arms extemely long, with photophores along their backs; very thin and sometimes becoming detached in part. Suckers on clubs in four, eight or more rows. Cartilaginous interlocking system present; cartilaginous groove ear-shaped, often elaborately constructed forming a strong generic character. Photophores may or may not be present on eyes, backs of arms, fins, head, and mantle. Gladius slender with narrow wings and long cone.

Genus Mastigoteuthis Verrill, 1881.

Mastigoteuthis Verrill, 1881*b*, p. 100. *Type*, M. agassizii Verrill. N. Atlantic.

Main characters of the family. Tentacular arms long, slender, with numerous rows of small suckers on clubs; clubs not expanded. Interlocking cavity ear-shaped, but simple. Photogenic organs numerous in some members, missing in others.

Chun (1908, p. 87) and Thiele (1934, p. 976) place *Mastigoteuthis* in the subfamily Mastigoteuthinae. MacDonald and Clench (1934, pp. 145–152) consider it inadvisable to retain this subfamily, since a new genus and species they describe from the North Atlantic is intermediate between the subfamilies Chiroteuthinae and Mastigoteuthinae. They prefer to regard *Mastigoteuthis* a member of the subfamily Chiroteuthinae. Further study of the group would have to be undertaken to substantiate this consideration.

Mastigoteuthis grimaldii (Joubin).

(Plate xxvi, figs. 18–21).

Chiroteuthis grimaldii Joubin, 1895, p. 38. North Atlantic.

Animal immature, slender, delicate. *Mantle* rising to a sharp point mid-dorsally: *ventral mantle* surface with little emargination. Mantle broad at anterior end, sloping rather rapidly to *fins*, from whence it forms a sharp spine-like portion throughout the length of the fins, and terminating just beyond them. *Fins* large, rounded, appearing very wide in proportion to body, mainly due to narrowness of mantle in their region. *Head* small, almost square. *Eyes* large, globular and protruding, set high in head.

Arms rather slender, short, except ventral pair, which are excessively long and broad, rather flattened, with a slight wing along the outer edges. Order of arms, 4, 2, 1, 3. *Suckers* on sessile arms, immature, delicate, scattered, and rather indistinct; on ventral arms in particular, they appear to be in more or less single irregular row, varying numbers being grouped together with a bare space between each group (fig. 20). *Tentacular arms* about half the width of ventral pair, very slender, but unfortunately their full length and the nature of the clubs are unknown as they are incomplete.

Funnel moderate size. *Cartilaginous groove* of interlocking system ear-shaped without tragus or anti-tragus, the corresponding *ridges* on inner ventral mantle elongate and fairly broad. Buccal area elevated, rounded, pustulose.

Small but conspicuous *photogenic tubercles* are scattered profusely over the ventral and dorsal surface of the mantle and head and round eyes, in a less degree on the fins, funnel, and up the back of the arms. A few almost indistinct ones appear to be on the back of the tentacular arms towards their base.

Colour.—Creamy-buff with dark chromatophores along back of arms and scattered over mantle in rather regular rows.

Measurements.—Mantle edge to tail, 13 mm. long, 4 mm. broad, tapering to 2 mm. at junction with fins. Fins, 10 mm. wide, 6 mm. long. Head, 2 mm. × 2 mm. (mantle edge to base of arms). Arms, 1st pair, 1 mm. long, 2nd pair, 3 mm., 3rd pair, 1 mm., 4th pair, 6 mm. long. Tentacular arms, incomplete, little more than length of ventral arms, but more slender.

Locality.—Station 17/38. 18/10/38. N.200. Hor. 42°40′S., 148°16′E. (near Maria Is., east coast, Tasmania). Shallow. One specimen.

Remarks.—As only one minute specimen of the family has apparently come to light in the collection, it is with reservation that I have identified it as *Mastigoteuthis grimaldii* (Joubin), the species I find it most closely allied to. The presence of photogenic tubercles scattered plentifully over the integument and other similarities bring it more into line with this than with others of the family, excepting perhaps *Mastigoteuthis flammeus* Chun (1910, p. 229, S. Atlantic). On the other hand, as only portion of the tentacles is present, a principal distinguishing characteristic, i.e., the structure of the clubs, is absent.

Our species does not resemble either *M. cordiformis* Chun, or *M. latipinna* (Sasaki), both of which have been recorded from Japan; nor does it coincide with *M. famelica* (Berry) from the Hawaiian Islands. In view of the immaturity of the specimen, and

the absence of the principal portion of the tentacles, it seems reasonable to regard it as a larval form of *grimaldii*, from which it is difficult to separate it, rather than a new species.

This interesting little specimen, appearing for the first time in these waters, has enabled the family to be recorded for the first time from the South Pacific.

Family Cranchiidae.

Body usually membraneous and transparent, with or without crystalline tubercles; nearly colourless. Mantle border firmly fused with head in nuchal region and with base of funnel on either side. Eyes usually large, often pedunculate. Sessile arms with two rows of suckers; tentacles with four rows of suckers, which may extend down the stalk for greater part of length. Hooks may occur in a few genera on tentacle clubs. Photogenic organs may be present on ventral eyeball, within pallial chamber, or may be entirely absent. Gladius slender. Pelagic or abyssal.

Two subfamilies are represented in the collection as set out in the following key:

a. Mantle smooth, without even a tubercled hyaline streak; a few tubercles may occur at point where mantle margin is attached to funnel or nape. Eyeball usually with one or two large photophores on ventral aspect. Stomach larger than caecum ..... *Taoniinae* Pfeffer 1912

aa. Mantle evenly beset with crystalline tubercles all over, or with tubercled hyaline streaks on ventral surface. Eyeball with 4-14 small rounded photophores. Stomach smaller than caecum ..... *Cranchiinae* Pfeffer 1912

Subfamily Taoniinae.

Genus Megalochranchia Pfeffer, 1884.

Megalocranchia Pfeffer, 1884, p. 24. Type, *Megalocranchia maxima* Pf. Cape of Good Hope.

? Megalocranchia pardus Berry, 1916.

(Plate xxvii, figs. 1–4.)

Megalocranchia pardus Berry, 1916, pp. 61–64. Type locality, Sunday Is., Kermadecs.

Animal small, delicate, with elongate cylindrical body tapering to slightly rounded point posteriorly, widest part little distance below *mantle margin*. *Fins* rounded, slightly more depth than breadth. *Head* short but broad; *eyes* large, protruding, globular, on short stumpy stalks, a large *photophore* with smaller one above it on each ventral eyeball. *Olfactory tubercle* on ventral surface of eye. *Arms* short and fairly stumpy, order 3, 2, 1, 4 (1 and 4 almost equal). *Tentacular arms* fairly long, very broad and strong, practically uniform width throughout, but in larger specimen have widened slightly to form definite *clubs* which have a keel on their outer angle. *Arm suckers* rounded, conspicuous, in two crowded rows; weakly dentate round edge; *tentacle suckers* profusely scattered over whole length of tentacle and club, in about 4–6 rows on club, changing to four rows on the lower portion, and for a considerable distance down stalk, towards the base of which the suckers are in two rows.

Funnel broad at base, hooded, reaching almost to level of eyes. Attached to mantle permanently on either side, in same manner as dorsal surface is attached to nuchal region. *Gladius* shows as a thin dark strip, widening towards base.

Colour.—Creamy-buff, upper part of eyes very dark. Dark red-brown *chromatophores* appear as regular bands round the backs of the tentacles, and rows of small dark *chromatophores* occur in regular rows on both dorsal and ventral mantle surfaces. These have become rather indistinct through preservation.

Measurements.—Mantle edge to tail tip, 11 mm. long, 5 mm. broad. Mantle edge to base of arms, 2 mm. long, 3 mm. broad. Eyes, 2 mm. long, 1 mm. broad. Largest arm less than 1 mm. long, ½ mm. broad. Tentacular arm 4mm. long, 1 mm. broad. Fins, approximately 1 mm. across. Total length, approximately 17 mm. (animal figured).

Locality.—Station 217/39. 6/9/39. N.200. D-0. 15 mm. (24 miles E. of Port Hacking, N.S.W.). Slope. One specimen, as above (figs. 1–3).—Station 63/38. 21/10/38. N.70. Vert. D.50–0. 43°13′S., 148°17′E. (near Port Arthur, S.E. Tasmania). Slope. One specimen (fig. 4), very much larger, which came to light after the examination of the

smaller specimen described above, and which seems a more mature form of the same species. Its measurements are: Mantle to tail, 30 mm., breadth 14 mm. Mantle edge to base of arms, 3 mm. Largest arm (3rd), 4 mm. long. Tentacular arm, 12 mm. Total length, approximately 45 mm. Other than considerable difference in size, no marked characters distinguish the two specimens.

Remarks.—I am in full accord with Berry (1916, p. 64), who remarked that the elucidation of the *Taoniinae* forms one of the most difficult taxonomic problems encountered in the study of the Cephalopoda. Species are represented in the collections by such scanty material, and their distinguishing characters are of such trivial nature, that the whole group needs careful rechecking by someone with access to types of older species and with sufficient fresh material for comparison. Only in this way can the difficulties associated with classification be overcome.

More so than perhaps elsewhere, does this apply to the few species recorded from the South Pacific. For this reason I have had considerable difficulty in allying the species above even with certainty to a genus, and since the larger specimen, in particular, seems to resemble Berry's illustration (1916, pl. ix, fig. 2) and description of *Megalocranchia pardus* from the Kermadecs so closely, I have with some hesitation named it as such, until more is known of the group in these regions.

In doing this, I have had to take into consideration the fact that both our specimens bear close resemblance to figures of *Teuthowenia megalops* (Prosch.) (N. Atlantic) and *Teuthowenia antarctica* Chun (S. Atlantic), the latter having been recorded from off North Island, New Zealand, by Massy (1916, pp. 170–1). Massy does not figure her species, other than radula and jaw, so it is difficult to know whether the species she names *T. antarctica* Chun is the same as our specimens, and whether it is a true *antarctica* rather than another species. However, the two localities—Kermadecs, and off North Island, New Zealand—are sufficiently close to cause one to wonder what relationship *Megalocranchia pardus* Berry may bear specifically to the *antarctica* recorded by Massy, particularly since some of the characters given by Berry appear to indicate *Teuthowenia* rather than *Megalocranchia.* Eventually Massy's species may prove to be identical with Berry's species.

The presence of another allied species in these waters has not been overlooked, namely, *Taonidium suhmii* (Lankester) (1884, p. 311), from between Sydney and Wellington, the type of which Hoyle (1886, p. 197) regards as two specimens from due south of Australia. This species is practically unknown, and until it is more firmly established, its relationships with the other allied species from these waters must remain uncertain. The four teeth on some of the tentacular suckers in Massy's *antarctica* appear to bring that species more in line with *suhmii* than with *M. pardus.* Further material, on the other hand, may prove the several species one and the same. I have endeavoured to supply accurate figures of our species that these may assist in future identification. In the meantime, the species has been determined, with reservation, as *Megalocranchia pardus* Berry.

Genus Bathothauma Chun, 1906.

Bathothauma Chun, 1906, p. 86. Haplotype, *Bathothauma lyromma* Chun.

Bathothauma lyromma Chun.

(Plate xxv, fig. 18.)

Bathothauma lyromma Chun, 1906, p. 86; 1910, pp. 389–391; Allan, 1940, pp. 321–324.

In 1940 I recorded the Cranchiid cephalopod, *Bathothauma lyromma* Chun, for the first time from the South-West Pacific, this interesting little species having been brought to light in a surface net of the *Warreen*, off Tasmania. In the present collection from the following stations are now further specimens which appear to be this species: Station 3A/38. 17/10/38 (off St. Helens, N.E. Tasmania). Slope. Three specimens. Total length, largest, approximately 10 mm.—Station 18/38. 24/10/38. N.100. Hor. 42°35′S., 148°37′E. (near Maria Is., E. Tasmania). Slope. One specimen, approximately 10 mm. total length.—Station 22A/38. 16/10/38. N.200. Hor. 39°42′S., 148°49′E. (off

Babel Is., N. Tasmania). Slope. One specimen. Total length, 23 mm.; mantle, 13 mm. × 9 mm. (figured).

They are similar to the specimen described in 1940, showing remarkably well the two-row arrangement of suckers along the stalks of the tentacular arms. The wrinkle-like folds at regular intervals round the whole mantle, which I considered then to be either a normal characteristic or due to preservation, have appeared in the same persistent manner in these later specimens, and I am still uncertain what to make of them. As similar ones do not show in this manner on other Cranchiids in the collection, the possibility of them being a characteristic of this species cannot be discountenanced.

The earlier specimen was collected on the same date in the same locality (off Babel Is., N. Tasmania), but from a different station, as the specimen in the present collection from Station 22A/38; the latter specimen shows most distinctly the folds referred to above.

Subfamily Cranchiinae.

Genus Pyrgopsis Rochebrune, 1884.

Pyrgopsis Rochebrune, 1884, p. 23. Type, *P. rhynchophorus* Rochebrune 1884.

Body elongate, sharply pointed, quite smooth, except for a tubercular longitudinal, crystalline streak running along each side of the ventral surface of the mantle. Mantle wide at anterior margin, very thin, membraneous. Fins terminal, moderate size, transverse-oval. Eyes pedunculate, eyeballs small, with 4–5 photophores on ventral periphery. Arms unequal, third pair longest, all bordered with membranes. Tentacular club well defined. Suckers on arms biserial, on clubs quadriserial, extending down stem for little way in single zig-zag fashion. Gladius broad.

Synonyms of this genus are *Zygaenopsis* Rochebrune 1884; *Zygocranchia* Hoyle 1908; and *Euzygaena* Chun. I have not seen Rochebrune's paper in which appeared his original descriptions of the genera *Pyrgopsis* and *Zygaenopsis*, but have studied their respective characters as set out by Mayer (1884, p. 23). Rochebrune apparently thought their distinguishing characters sufficiently strong to separate them generically, but Pfeffer (1900, p. 193) regarded them as synonymous, a synonymy retained by Thiele (1931, p. 978).

Pyrgopsis pacificus (Issel).

(Plate xxvii, figs. 5–11.)

Zygaenopsis pacificus, Issel, 1908, p. 223.

Animal long, slender, gelatinous, very transparent in immature specimens; *mantle* much wider than head at margin, sloping rapidly to a sharp point posteriorly. Mantle attached permanently at *nuchal point* mid-dorsally, and on each side of *funnel*, as in family. From the points of attachment to funnel, to about half-way down each side of ventral surface, is a conspicuous row of crystalline tubercles. The upper half of the line consists of about eight very conspicuous compound tubercles arranged on a continuous fleshy ridge, with about 1–4 small simple tubercles between each one. After about the eighth large tubercle, approximately 10–12 equally-spaced crystalline tubercles are attached direct to the mantle. In a series of specimens from various Stations, from minute forms of a few millimetres to those of appreciable size, the tubercles were always present, although sometimes reduced in size and number in the less mature specimens.

Fins fairly wide and large, roundly pointed, meeting at extreme posterior end. *Head* small, widest towards its junction with mantle, becoming very narrow and elongated from the base of eyes towards arm-bearing portion of animal. *Eyes* large, conspicuous, on long, plump stalks; a few small indistinct *photophores* indicated on ventral surface of eyes in some specimens. *Funnel* large and wide at base, hood shaped, with upper margin indented in centre. *Sessile arms* short, firm, order of length 3, 2, 4, 1, the third pair very much longer and broader than the others; *suckers* fairly large, round, flattish, arranged in two slightly oblique rows on the arms, about 10 rows on the dorsal arms and 29 rows on third pair of arms. *Tentacular arms* fairly long, strong, widened into a club head at the end, with a pronounced wing. Suckers on club in rows of four, minute

at tip, increasing gradually in size until about the 16th row; then follow four rows of two very large suckers with a smaller sucker on each side (fig. 7), a few rows of small suckers again and some scattered suckers for a short distance along stalk in a single row. On the inner ring of the suckers are numerous minute pustules, the innermost row of which in certain lights extends beyond the ring, suggesting a serrated appearance.

Gladius appears as a reddish-brown ridge down dorsal surface.

Colour.—General colour of larger specimens creamy-buff with dark reddish-brown *chromatophores* round eyes. Brown chromatophores, indistinct in many specimens, are arranged in about 9 rows round dorsal and ventral mantle surface, and along the backs of the tentacular arms. Brown speckling also occurs along the backs and sides of the latter. There is a large chromatophore at base of dorsal arms, and behind funnel. Smaller specimens are colourless, with little or no marking.

Measurements (fig. specimen).—Mantle to tail, 72 mm. long, 20 mm. broad. Fins, 18 mm. long, 30 mm. width across. Mantle edge to base of arms, 8 mm. Width of neck at base of arms, 4 mm. Tentacular arms, 30 mm. long. Arms, 1st pair 4 mm., 2nd pair 7 mm., 3rd 20 mm., 4th 5 mm. Eye—plus stalk—10 mm. long, 4 mm. broad. Approximate total length, tail to tip of tentacular arm, 110 mm.

Locality (figured specimen).—Station 62/38. 16/10/38. N.100. Hor. 39°37′S., 148°52′E. (Bass Strait, near Babel Is., Tasmania). Slope. One specimen.

Localities of other specimens taken, with their mantle measurements, are as follows: Station 217/39. 6/9/39. N.70. Obl. D-200 (24 miles E. Port Hacking). Slope. One specimen. Mantle 23 mm. × 6 mm.—Station 200/39. 7/10/39. 30°17′S., 153°34′E. (near Coffs Harbour, N. Coast, N.S.W.). Shallow. One specimen. Mantle 15 mm. × 6 mm.—Station 187/39. 12/6/39. Off St. Helens, Tasmania. Slope. Two specimens. Mantle 22 mm. × 6 mm.—Station 217/39. 6/9/39. N.70. Vert. D.100–50 (24 miles E. Port Hacking). Slope. One specimen. Mantle 15 mm. × 6 mm.—Station 138/39. 16/5/39. N.70. Hor. 30°56′S., 153°21′E. (near Trial Bay, N. N.S.W.). Slope. Nineteen specimens. Mantle, largest 16 mm. × 5 mm., smallest 5 mm. × 2 mm.—Station 144/39. 31/5/39. N.100. Hor. 36°15′S., 150°25′E. (near Montague Is., S. coast, N.S.W.). Slope. Four specimens, 28 mm. × 8 mm., 11 mm. × 4 mm., 9 mm. × 4 mm., 8 mm. × 3 mm.—Station 188/39. 13/6/39. N.200. Hor. 39°54′S., 149°36′E. (north of Babel Is.). Shallow. Three specimens. Mantle, largest 15 mm. × 6 mm.—Station 214/39. 5/9/39. N.70. Obl. (N.S.W.). One specimen. Mantle, 24 mm. × 8 mm.—Station 127/39. 3/5/39. N.100. Hor. 33°18′S., 152°13′E. (near Norah Head, N.S.W.). Slope. Two specimens, 13 mm. × 4 mm., 5 mm. × 2 mm.—Station 128/39. 3/5/39. N.100. Hor. 32°37′S., 152°22-30′E. (near Seal Rocks, N. coast, N.S.W.). Shallow. Two specimens, 10 mm. × 5 mm., 6 mm. × 3 mm.—Station 143/39. 31/5/39. N.200. Hor. 35°07′S., 150°50′E. (near Jervis Bay, N.S.W.). Shallow. One specimen. 10 mm. × 4 mm.—Station 66/38. 12/11/38. N.200. Hor. 35°07′S., 150°51′E. (near Jervis Bay). Shallow. One specimen. Mantle 50 mm. × 12 mm.

Remarks.—This very graceful cephalopod was the most common species in the collection. Apart from a single specimen recorded from off Three Kings Island, N. Zealand, and off North Island, N.Z., by Massy (1916, p. 168–9), the genus has not been recorded before from the South-West Pacific, but has been described from Japan (Sasaki), Tahiti and South Africa (Issel), and Atlantic (Chun). This is the first occasion therefore that it has been associated with Australia or Tasmania. The large number of specimens, especially nineteen from one locality—Station 138/39—provides another interesting factor.

In view of the distribution so far recorded for *Pyrgopsis pacificus* (Issel), I have identified the above specimens as this species rather than *P. schneehagenii* (Pfeffer, 1884, p. 23, fig. 21), type locality Chili, which it also resembles. The difference between *pacificus* and *schneehagenii*, indeed, seems such that it is conceivable at some future date they may prove synonymous. The crystalline tubercles on some of our specimens appear to extend further down the mantle than they do in the illustration of Chun's specimen (1910, taf. lii, figs. 1–3).

Suborder MYOPSIDA.

Family Sepiolidae.

Body short, thick, rounded posteriorly. Fins large, separate, rounded or ovate, attached laterally towards middle of body. Mantle joined to body by a retractor muscle reinforcing the median septum of mantle cavity. Gladius rudimentary or absent. Large saddle-shaped photogenic organ sometimes present overlying the ink-sac, emitting a luminous secretion. Distribution—all seas.

Two subfamilies are represented in the collection, as set out in the following key:

a. Mantle margin free all round; a cartilaginous articulation in the nuchal region of dorsal margin but dorsal mantle and viscera may be fused further back along mid-dorsal line. Fins large; arms with fairly broad web uniting them. Right dorsal arm hectocotylized. Photogenic organs usually very large, nearly covering ventral surface of ink-sac, closely conjoined down medium line. Pelagic subfamily of few genera and species .... *Heteroteuthinae,* Appellof 1898

aa. Mantle continuous with head at nape of neck dorsally, its ventral margin articulating with funnel by cartilaginous locking system. Fins ear-shaped anteriorly. Web between third and fourth pairs of arms forming a sheath for each tentacular arm. Left dorsal arm of male hectocotylized. Saddle-shaped photogenic organ large and well developed, except in genus *Inioteuthis* ..... *Sepiolinae* Hoyle 1904

Subfamily Heteroteuthinae Appellof.

Genus Heteroteuthis (Gray), 1849.

Rossia (*Heteroteuthis*) Gray, 1849, p. 90.

Body plump, compact, obtusely pointed behind. *Fins* large, semicircular; *ventral margin* produced forward above head, almost or entirely covering the funnel. *Arms* short, webbed except between ventral pair. Right dorsal arm (hectocotylized) united at base with 2nd right arm. Type, *Sepiola dispar* Ruppell 1844, Mediterranean region.

This is the first record of this subfamily in Australian waters. Berry (1909, pp. 409, 418) records a new species, *Stephonoteuthis hawaiiensis*, later placed under *Heteroteuthis* by Naef (1912, p. 246), from Hawaiian Islands. The only other species of the genus appears to be *H. weberi* Joubin (1902, p. 113) from Dutch East Indies, which unfortunately is not figured by Joubin. The recorded distribution of the genus *Heteroteuthis* now becomes Mediterranean, Dutch East Indies, Hawaiian Islands, and Australia.

Heteroteuthis serventyi, sp. nov.

(Plate xxvii, figs. 22, 23.)

Animal well developed, small, solid, plump, but the skin loose to touch. *Mantle* almost straight sided, tapering to rounded point posteriorly. *Mantle edge* free all round, connected to head by strong interlocking cartilages ventrally, the ridges of which commence some little distance from the ventral edge. Dorsal mantle edge is slightly but broadly arched, rising to a high peak behind each eye on the ventral surface; between the peaks the ventral margin forms a broad emargination just below the top of the *funnel.* Ventral surface of mantle is very broad and swollen, much more so than the dorsal surface, flattening just below half-way to the tail. *Fins* large, oval, situated laterally, about midway along the sides; their anterior and posterior edges are equidistant from mantle edge and tail respectively.

Head very broad, narrowing in above eyes towards base of arms. *Eyes* very large, rounded; ventral head area deeply excavated between them. *Arms* very short, web about half-way up their length; shorter dorsally, increasing in size towards ventral pair which are longest and strongest. Order of sessile arms, 4, 3, 2, 1. *Suckers* on arms biserial, quite large but smaller towards tips. *Tentacles* long, about as thick as arms, with a ridge down the inside centre. The *club* on each tentacular arm is curled over and resting on an expanded portion of the tentacle just below the club. Club bears numerous minute suckers.

Funnel rather small, narrowing towards opening. Funnel groove wide at top, narrower towards base, with a notch towards the inner edge.

Colour.—General appearance of body dark reddish-brown with light-buff fins, arms, and tentacles, and a luminous glow all over. There is a patch of rich dark-purple colour between the eyes dorsally. The eyes are very beautiful with golden-bronze hue. Two brilliant, very large green-bronze photogenic (luminous) organs lie at the base of the funnel, completely covering the ink-sac; they are united along their inner sides, and have a small rounded pore on their upper surface.

Measurements.—Mantle, dorsal edge to tail tip, 7 mm. long, 6 mm. wide. Head, mantle to web, 5 mm. long, 5 mm. wide. Dorsal arms, web edge to arm tip, 2 mm., ventral arms, web to tip, 3 mm. Fins, 5 mm. long, 3 mm. wide at widest part.

Locality.—Station 66/38. 12/11/38. N.200. Hor. 35°07′S., 150°51′E. (near Jervis Bay, S.E. New South Wales). Shallow. One specimen.

Remarks.—This little cephalopod must be very beautiful in life, and it is regretted that only one specimen has so far come to light. It is fortunate, however, that the subfamily can now be recorded for the first time from these waters. The species is close to *H. hawaiiensis* Berry, but differs in a number of points and particularly in the ventral mantle margin not entirely concealing the funnel and head. The description of *H. weberi* Joubin also suggests a close association with that species, but in view of the location of the Australian species, I doubt that these are other than closely allied species to it, and therefore propose the specific name of *serventyi* for our species.

Subfamily Sepiolinae Hoyle, 1904.

Genus Euprymna Steenstrup, 1887.

Euprymna Steenstrup, 1887*a*, p. 66; 1887*b*, pp. 89, 90. Genotype *Inioteuthis morsei* Verrill, 1881. Japan.

Nuchal commissure far broader than one-third breadth of head. Fins small, attached little nearer mantle margin than posterior end. Arm suckers in four oblique rows, small and similar in female, unequal in male, several in one or both marginal rows being especially enlarged. Suckers on tentacles minute, crowded. Left dorsal arm hectocotylized, provided with swollen, modified suckers tightly palisaded together in 2–4 series on distal half. Saddle-shaped photogenic organ present, conspicuous. Gladius absent.

Euprymna tasmanica (Pfeffer), 1844.

(Plate xxvii, figs. 20, 21.)

Sepiola tasmanica Pfeffer, 1884, p. 6. Holotype, Bass Strait.

Animal small, very immature, *body* oblong-rounded, *mantle* sides almost straight, sloping to rounded point towards posterior end. Attached to nape of neck from just below dorsal edge of eyeball, *nuchal commissure* being almost half width of head. Ventral margin interlocking with head, and has a bare area running along its breadth and extending a short distance down mantle, as illlustrated in figure of *Euprymna tasmanica* Pfeffer by Cotton and Godfrey (1940, p. 406).

Fins small, about one-third length of mantle, slightly narrower at junction with mantle, rounded, but anterior end lobed. *Head* squarish; *eyes* normal, set fairly far apart. *Arms* rather long, tapering, about same length as head, order 2, 3, 4, 1, but close in size; a pronounced web between 3 and 4. *Suckers* on arms irregular in size, globular. They are easily rubbed off, and most of them are absent, only a small mound indicating their original position. The remaining suckers, many of which appear to be in biserial order, resemble those of a male *Euprymna*, although there is no modification in the left dorsal arm. *Tentacles* exposed short distance beyond arms, almost same thickness. *Clubs* curled over; suckers minute, numerous in about eight rows.

Funnel elongated and almost tubular, extending almost to base of ventral arms, widened at base. Two large, whitish, saddle-shaped *photogenic organs* overlie the *ink-sac*; they have a dark border, and are united down their inner margins.

Colour.—Creamy-buff mantle and arms; head darker; *eyeball* bronze-gold. The same luminous tinge is present over the ventral surface of head. A few scattered minute dark-brown spots overlie the mantle.

Measurements.—Mantle, tail tip to nape, 5 mm. long, 4 mm. broad. Head 3 mm. long, 3 mm. broad. Longest arm 3 mm.

Locality.—Station 184/39. 11/6/39. 42°38′S., 148°13′E. (near Maria Is., east coast, Tasmania). N.200. Hor. Shallow. One specimen (figured).—Three minute specimens from Station 45/38. 17/9/38. N.70. Vert. D.50–0. 24°20′S., 153°02′E., seem larval *Euprymna* but, owing to the extreme northerly locality of these specimens (near Heron Island, Great Barrier Reef), they may be larval forms of *Euprymna stenodactyla* Grant, a north-eastern Australian species. The total length of the largest specimen being only 3 mm., it is impossible to place them with certainty in that species.

Remarks.—Although in places there appear to be only two rows of irregular sized suckers on the arms of the specimen here identified as *tasmanica*, they are so easily removed that it is quite possible there could be two rows of much smaller ones intermixed with the larger marginal suckers, as shown in Sasaki's illustration of *E. morsei* Verrill (Sasaki, 1929, p. 144). The broad nuchal commissure reaching more than half the width of the head removes it from *Sepiola* Leach 1817, a genus which it superficially seems to approach. Its southern locality, so closely approaching that of the holotype, leaves little doubt that this is a larval form of *Euprymna tasmanica* Pfeffer.

Family Idiosepiidae.

Myopsid cephalopods with elongate bodies and rudimentary subterminal fins. Gladius lost and replaced by a singular ring-like tendinous support. Head separated from dorsal margin of mantle. Arm suckers biserial, tentacle suckers bi-quadriserial. Both ventral arms hectocotylized. Distribution, Indian and Pacific Oceans.

Berry (1921, p. 353–362), in his review of the family, erected a new species *Idiosepius notoides*, carrying the distribution of known species to southern Australia. Cotton and Godfrey (1940, p. 398–400) have recently dealt briefly with the four known species of the family.

Genus Idiosepius Steenstrup, 1881.

Idiosepius Steenstrup 1881, p. 219–224. Genotype, *Idiosepius pygmaeus* Steen. Dutch East Indies and Zamboanga, Philippines.

Characters of the family. Interlocking cartilage broadly oval with corresponding small ridge. The only genus of an unusual family; few species are so far known.

Idiosepius notoides Berry, 1921.

(Plate xxv, figs. 19, 20.)

Idiosepius notoides, Berry, 1921, p. 361–362. Goolwa, South Australia.

Animal small, *mantle* roundly pointed, cylindrical; *fins* small, almost terminal in position, semi-circular. *Head* large, almost as wide as body, to which it is attached ventrally by a strongly developed button-like, interlocking system, the ridges on the inner ventral mantle surface being short, but prominent (fig. 19). *Eyes* large, set high up in head, slightly oval in shape, with rather elongate pupil. Olfactory *papillae* present.

Arms short, rounded on back, 2nd pair longest, remainder fairly equal, 3rd and 4th arms on each side united by a web forming a sheath for the tentacular arms. *Suckers* on arms fairly crowded, small, biserial. *Tentacles* short and stout, retracted almost to level of arms in the specimen. *Clubs* large, occupying the whole of the exposed length of tentacles. Suckers extending well down tentacles, in two rows on upper portions, crowding to four rows lower down. The outline of the tentacles can be traced well down between the eyes ventrally (fig. 19). *Funnel* rather short, hood-shaped, reaching to about level of olfactory papillae. There is a conspicuous bronze-gold *photogenic organ* over the *ink-sac*. I am unable to make out the structure of the *gladius*, and can see no evidence of hectocotylization on the ventral arms as indicated by Berry.

Colour.—Deep uniform cream with small blackish-brown dots scattered more or less regularly over the entire surface of the mantle, some of which appear almost slightly elevated. Larger but fewer patches of the same colour occur along the backs of arms and on the head. Eye areas very dark.

Measurements.—Mantle edge to tail, 5 mm. long, 3 mm. broad. Head 2 mm. long, 2 mm. broad. Longest arm (2nd pair) 2 mm. (figured specimen).

Locality.—Station 188/39. 13/6/39. N.200. Hor. 39°54'S., 148°36'E. (near Babel Island, Bass Strait). Shallow. Two specimens, one minute, the other described above.

Remarks.—Various authors, in reviewing the family Idiosepiidae, make no reference to a photogenic organ overlying the ink-sac, as has been noticed in this specimen from Bass Strait. That this has been overlooked is quite possible, since there seems little doubt our species belongs to this family. The large head, small, separated, subterminal fins, and the character of the arms and suckers are typical of the genus, and in view of its southern locality, it can safely be identified as an immature form of *Idiosepius notoides* Berry. None of the species so far described appear to have a mantle length much more than 25 mm. (the male being slightly smaller than the female). The type of *Idiosepius notoides*, which is the second largest species described, has a mantle length of approximately three to four times that of the "Warreen" specimen from Bass Strait.

As far as I am aware, this is the first occasion on which the complete animal has been figured. It is regretted that more and larger specimens were not available for examination.

Sasaki (1929, p. 134) gives some interesting habits of *Idiosepius paradoxus* Ortmann, the only species known by Sasaki to inhabit Japanese waters. He says it is littoral in habit, usually adhering its back (dorsal surface) on the undersurface of seaweeds, for which purpose a special adhesive organ—a wrinkled and glandular area occupying the posterior portion—is developed on the back. Sasaki also gives an interesting account of its feeding and mating habits.

Order OCTOBRACHIATA (OCTOPODA).

The octopods were poorly represented in comparison to the Decapoda, only three families occurring in the collection, but two of these, Amphitretidae and Bolitaenidae, are placed on the Australian list for the first time.

The key to the families is as follows:

a. Mostly littoral animals, body usually firm, no fins. Arms with one or two rows of suckers and more or less well developed basal web ..... *Octopodidae*

aa. Pelagic or abyssal. Body gelatinous. Umbrella present in varying degrees, sometimes greatly developed. Suckers mostly in single row. No fins.

b. Ventral margin free and wide, animal semi-transparent and semi-gelatinous. Eyes elongate, situated dorso-laterally. Umbrella present in varying degrees. Suckers uniserial on arms ..... *Bolitaenidae*

bb. Ventral margin only free at two small orifices between the eyes and siphon, forming pallial apertures. Eyes dorsal, close together, telescopic in appearance. Umbrella greatly developed ..... *Amphitretidae*

Family Octopodidae.

Genus Octopus Lam., 1798.

Octopus Lamarck (1798, p. 130). Genotype.—*Octopus vulgaris* Lam.

Body short, rounded, thick; surface either smooth or warty, usually with one or more tentacular cirri over each eye. Length of arms or size of web variable. Suckers in two alternating rows, at times appearing as a single zig-zag row. Third right arm hectocotylized.

Octopus pallida Hoyle, 1885.

(Plate xxvii, fig. 15–18.)

Octopus pallida Hoyle, 1885*a*, p. 223; 1886, pp. 81–83, 88.—Bass Strait; Twofold Bay, N.S.W.

Animal rounded, very small, *mantle* free ventrally, from just below eye. *Head* almost as wide as body. *Eye* fairly small. *Arms* rather short, fairly equal, 2nd and 3rd pairs slightly longer. *Suckers* crowded, large, especially the middle ones; last two in a single row on each arm. *Web* about one-third length of arm.

Funnel broad at base, sloping to narrow opening anteriorly, reaching almost to base of ventral arms, between which there appears very little web. Over surface of head, backs of arms and body is fine sprinkling of small scattered *pustules*, not very conspicuous or prominent except in one or two specimens in which suggestion of rosette-shape is noticed and some cirri can be faintly recognised.

Colour.—Creamy-buff, darker round head. In a small species which seems the same, a single row of well-separated dark red-brown squarish *chromatophores* runs along the centre of the back of each arm, whilst a row of minute dark dots is present between the base of each sucker along both sides of the arms (see fig. 18). Large markings are scattered over ventral surface of body.

Measurements.—Mantle, 7 mm. long, 7 mm. maximum width. Head, mantle edge to web edge, 4 mm. long, 6 mm. broad. Ventral arms, 6 mm. from mouth to tip.

Locality.—Station 60/38. 12/10/38. N.200. Hor. 43°13′S., 148°17′E. (near Pt. Arthur, S.E. Tasmania). Slope. One specimen (fig. 17).—Station 22A/38. 16/10/38. N.200. Hor. 39°42′S., 148°49′E. (N. of Babel Is., Bass Strait). Slope. One specimen, 6 mm.—Station 96/38. 12/12/38. N.100. Hor. 36°19′S., 150°26′E. (near Montague Is., N.S.W.). Slope. One specimen (fig. 18).—Station 43/38. 14/9/38. N.70. 30 mm. Hor. 24°41′30″S., 152°45′E. (near Bundaberg, Queensland). Shallow. One specimen, 7 mm. × 3 mm.—Station 103/39. 9/8/39. N.200. Hor. (near Broughton Is., N. Coast, N.S.W.). One specimen, 7 mm. total length.—Station 192/39. 14/6/39. N.70. Vert. 37°13′S., 150°22′E. (near Twofold Bay, N.S.W.). Slope. One specimen, 2 mm. total length.—Station 41/40. 7/5/40. N.100. 42°23′S., 148°43′E. (near Oyster Bay, E. Tasmania). Slope. One specimen, total length 5 mm.—Station 186/39. 12/6/39. N.200. Hor. Slope. 41°14′S., 148° 25′E. (N.E. Coast, Tasmania). One specimen, 5 mm.—Station 63/38. 21/10/38. N.70. Vert. 43°13′S., 148°17′E. (near Oyster Bay, Tasmania). Slope. One specimen, 5 mm.—Station 62/38. 16/10/38. N.200. 39°37′S., 148°52′E. (N. of Babel Is., Bass Strait). Slope. Two specimens, 7 mm. total length.—Station 212/39. 25/8/39. N.70. Obl. (near Twofold Bay, N.S.W.). Shallow. One specimen.—Station 144/39. 31/5/39. N.200. Hor. 36°15′S., 150°25′E. (near Montague Is., N.S.W.). Slope. One specimen, 8 mm. × 4 mm.—Station 6A/38. 18/10/38. N.200. 42°40′S., 148°16′E. (near Maria Is., Tasmania). Shallow. One specimen, 5 mm.

Remarks.—Though larval, the above forms show characteristics of *O. pallida* rather than other known species from Australian waters, the majority of stations from which they were taken falling within the range of *pallida*, namely, southern Australian regions, New South Wales, and New Zealand. I have therefore regarded them as approaching most closely to this species. The Queensland specimen from Station 43/38. 14/9/38 has a more elongate body than the other forms, and is attractively marked with dark chromatophores (figs. 15–16). It is possible that this is a different species.

Octopus ?tetricus Gould, 1852.

((Plate xxvii, fig. 19.)

Octopus tetricus Gould, 1852, p. 474, f. 588. Type locality, Twofold Bay, N.S.W.

Animal small, immature, more elongated than previous species. *Mantle* elongate-oval with furrow down mid-ventral surface; about same length as arms and web combined; free ventrally from just below mid-eye level. *Arms* fairly even, *2nd* and *3rd* pairs seem slightly longer than remainder; web extends about two-thirds up arms. Funnel seems attached to head due doubtless to its immaturity. *Suckers* on arms are crowded, small, very minute for a number of rows at tips.

Body marked with small, closely-set *tubercles*, crowded and conspicuous on the backs of arms in particular, giving a strong granulated appearance.

Colour.—Dark greenish with bronze hue round the anterior portion of the eye area. Underlying the greenish colour can be faintly seen small brown chromatophores in two rows up the backs of arms and smaller rounded ones over the tail.

Measurements.—Mantle, 6 mm. × 4 mm. Head, 3 mm. × 3mm. Mantle edge to web, 4 mm. Longest arm, 4 mm. Total length, approximately 14 mm.

Locality.—Station 104/39. 10/4/39. 40°38′S., 147°57′E. (N.E. Tasmania, Bass Strait). Shallow. 2 specimens (fig. 19).—Station 103/38. 4/12/38. N.70. Hor. 34°5′S., 151°14′E. (near Port Hacking, N.S.W.). Shallow. Two specimens; though only 2 mm. total length, these have granulated appearance of the above specimens and may be regarded as still younger forms of the same species.

Remarks.—The specimens I have considered young of *tetricus* are about the same size as the previous species, but are readily distinguishable from it by the much smaller suckers, longer and narrower head, small eyes and the tuberculate nature of the surface, intensified on the backs of the arms. They somewhat resemble the illustrations given by Berry (1918, pls. lxxix, lxxxi) of *O. variolatus* Blainville, but in general outline do not resemble Hoyle's figure of *O. pallida* Hoyle (1886, pl. i), of which *variolatus* is considered a synonym.

Family Bolitaenidae (Chun) Naef.

Sasaki (1920, p. 170; 1929, p. 12) uses the family name Eledonellidae for three genera, *Eledonella* Verrill, 1884, *Chunella* Sasaki, 1920, *Japetella* Hoyle, 1885, and *Vitreledonella* Joubin, 1918, but Thiele (1934, p. 988) and Robson (1931 (1932*b*), p. 326) prefer Bolitaenidae Chun, 1910, as the more acceptable family name for this group of peculiar little cephalopods. Also Thiele and Robson place *Vitreledonella* in the family Vitreledonellidae, and not in Bolitaenidae, but are at variance, however, in the position of some genera in Bolitaenidae. Thiele, for instance, regards *Japetella* Hoyle and *Bolitaena* Steenstrup as the two main genera, with two subgenera to the latter genus, *Bolitaena* s.s., and *Eledonella* Verrill (type, *B.* (*E.*) *pygmaea* Ver.). Robson, however, maintains *Eledonella* as a genus.

That the status and relationships of the various genera in this family have caused much uncertainty is shown by Bouxin and Legendre (1936, pp. 12–22) in their systematic account of the group. Unlike Robson and Thiele, they follow Sasaki in the use of the family name Eledonellidae, and use *Bolitaenella* Grimpe, 1922, rather than *Japetella* for the species *diaphana* Hoyle. Classification of the genera seems based largely on the structure of the peduncular and optical ganglion, necessitating ample material for comparison. The appearance of a representative of the family in Australian waters provides a further instance of the extraordinary planktonic fauna hitherto unrecorded from these regions.

Genus Eledonella Verrill, 1884.

Eledonella Verrill, 1884, p. 144. Type, *E. pygmaea* Verrill. New England Coast.

Characters of family. Body soft, saccular; mantle extending forward as far as eyes; arms slender, third pair longest, third right arm hectocotylized by having terminal half thickened and somewhat shortened, and bearing on its distal half a few very large suckers. Interbrachial membrane short. Eyes well developed, nearly covered by skin; a mucus-pore close to the anterior ventral border of the orbit. Siphon moderately developed, free only near the tip. A large median ventral commissure joins mantle to viscera, dividing gill chamber into right or left. Optic nerve long.

Eledonella sheardi, sp. nov.

(Plate xxvi, figs. 22–27.)

Animal very small, soft, gelatinous, semi-transparent. *Body* somewhat broad, rounded, continuous with head dorsally, free ventrally. *Mantle* edge extending to about mid-eye, reaching well over head ventrally, capable of being flattened; *pallial opening* very wide. *Head* fairly short, appearing especially so ventrally. *Eyes* enormous, situated laterally, but produced dorsally and ventrally into prominent rounded prolongations. The *eyes* are covered with skin, which forms a conspicuous *mucus-pore* on the ventral surface about in centre of pupil and shows signs of similar puckering on each extended portion. On removing the skin from one eye, the pupil is found to be very globular, with a dark greenish bronze luminous sheen. The prominences on each end are very dark, resembling those on the eyes of some of the Cranchiidae and, I feel sure, possess some luminous quality, but I refrained from interfering with them on account of the rarity of the species and the delicateness of its structure (fig. 27). The eyes on first appearance give the impression of double eyes, due to the pupil being hidden, and the ventral and dorsal extended portions being so prominent. The size of the eyes considerably increases the width of the head which would be otherwise narrow. A slight depression indicates the junction of the head and mantle dorsally. Round the base of

the eyeball on the ventral surface runs a fairly wide furrow. An *olfactory papilla* is present below each eye.

Arms fairly short, third pair the longest and broadest, others almost equal. *Suckers* large, rounded, sessile with wide openings, arranged in single straight row, 5–6 in a row with suggestion of minute ones at extremity (fig. 24). *Umbrella* between arms very delicate and easily torn, reaching only a little way up arms. No sign of hectocotylization.

Funnel almost hidden by mantle edge, reaching only about mid-eye; fused throughout its length to ventral surface of head; slipper-shaped in appearance, fairly small, elevated and rounded anteriorly, sloping to almost a point posteriorly. *Funnel opening* situated half-way down the funnel, conspicuous, oblong and wide. In other members of the family, the funnel opening is either right at the extremity or just below it. The opening is completely hidden by the mantle, although its outline can be seen through the semitransparent tissue. Ventral mantle adheres to the viscera by a muscular band, some distance below the funnel base. The *gills* are small, consisting of about 5–7 filaments on the outer demibranch, as far as can be ascertained.

Colour.—Yellow-liverish with suggestions of minute dark chromatophores over the body. A darker area on the head and round the eyeballs. Through the back of the arms may be seen two parallel dark bands running down their length.

Measurements.—Mantle, 7 mm. long, 5 mm. broad. Nape (junction of head and mantle) to arm tips, 4 mm. Head, width from eye to eye, 3 mm.

Locality.—Station 219/39. 15/9/39. N.200. Obl. 28°44′S., 153°57′E (near Cape Byron, N. Coast, N.S.W.). Slope. One specimen.

Remarks.—The large eyes, covered with skin, forming a mucus-pore on the ventral side, the widely extending mantle, and the funnel attached to the head approach more closely the characters of Verrill's genus *Eledonella* than other genera in the family. Certainly in Verrill's description the funnel is not attached completely throughout its length, but "free only near the tip", which may be a specific difference. Also Verrill does not mention generically or specifically the position of the funnel opening, or the prominent dorsal and ventral extensions of the eyes, but he does mention the skin over the eyes forming a mucus-pore, as in the above species.

The specimen under consideration does not appear to be *Japetella diaphana* (Hoyle) from various localities, including New Guinea (*Challenger*) and Japan (Sasaki); or *J. prismatica* Hoyle, owing to differences in the eyes and funnel. It more closely approaches *Eledonella ijimai* Sasaki (1929, p. 13), but the web in that species extends further up the arms, the funnel is completely covered by head tissues, and the eye "rather small projecting dorsally and lateral", whilst the large eye, dorso-ventrally extending from the base of the head to base of arms; and the slipper-shaped funnel, with opening half-way down, attached throughout its length to the head, seems definitely to remove the Australian species from any previously described form of the family Bolitaenidae, and I therefore propose the new specific name *sheardi* for it.

Although I have placed this species in the genus *Eledonella* for the time being, it is not without lengthy consideration of available literature on the family and the status of the various genera and species. Robson's comprehensive monograph of the cephalopods (1931 (1932)*b*, pp. 326–335) clearly shows the difficulty experienced in trying to elucidate this family, and the extent to which some members, such as *Japetella diaphana* (Hoyle) have been classified and reclassified generically again and again. Even in removing Sasaki's species *ijimai* from the genus *Eledonella* into *Bolitaena*, Robson admits the position is by no means certain and its inclusion in that genus is somewhat arbitrary. It is quite possible that our species will later prove a distinct genus, but I do not feel justified in assuming this on the single, apparently immature specimen in the collection.

The fact that the family Bolitaenidae has not previously been recorded from Australia, and is now only represented by this extraordinary little cephalopod, seems to warrant the rather full explanation given above. Should it later be found to possess *photophores* on the extensions of the eyes, as their appearance suggests, this will prove a

most interesting revelation, since the genus *Melanoteuthis* Joubin, 1912, has been the only group of Octopods so far regarded as possessing luminous organs.

Family Amphitretidae Hoyle, 1885.

A pelagic family of graceful appearance represented so far by a single genus, *Amphitretus* Hoyle. Distribution, S.W. Pacific, Japan, Cape Town.

Genus Amphitretus Hoyle, 1885.

Amphitretus Hoyle, 1885*a*, p. 235; 1885*b*, p. 271; 1885*c*, p. 113; 1886, p. 67.

The pallial aperture is reduced to two small orifices between the eyes and the funnel. Eyes are dorsal in position, close together and telescopic in appearance. Umbrella greatly developed with little or no differentiation between it and the head. The outer skin of animal is very soft, loose and gelatinous, forming a layer over body, head and umbrella. Represented by two species, *pelagicus* Hoyle, and *thielei* Robson, 1930.

Amphitretus pelagicus Hoyle, 1885.

(Plate xxvii, figs. 12–14.)

Amphitretus pelagicus Hoyle, 1885*a*, p. 235; 1885*b*, p. 271; 1885*c*, p. 113; 1886, p. 67. Kermadec Islands.

Animal very small, immature. Integument soft, gelatinous, almost transparent and sufficiently loose to enable the animal to be moved into various shapes, but at the same time rendering it very difficult to handle. *Body* rounded, no demarcation between *head* and *umbrella*, but muscular parts of arms are discernible through the skin of the umbrella. *Eyes* large prominent, telescopic-looking knobs situated close together on dorsal surface. *Umbrella* is very wide, transparent, extending about two-thirds up the length of arms. *Arms* very short and delicate, especially 3rd and 4th pairs. Within the umbrella they provide little support, but serve mainly as soft tissues for the reception of sessile *suckers*. *Suckers* fairly firm, rounded, 13–16 in a single straight row on each arm, crowded at tips, becoming more spaced towards their base. No biserial arrangement towards the free extremities of the arms, as referred to by Hoyle, can be seen.

Funnel very soft, flabby, fairly long with small opening. Free throughout its length, but adhering to mantle at its sides ventrally. *Mantle* opening reduced to small, well-developed opening each side of ventral surface between funnel and eyes, a little nearer to latter and on about the same level (fig. 14). The opening seems capable of stretching, and appears as a depression in the skin, but in reality opens into an inner pocket-like area leading into a compressed passage, which in turn appears to lead into the branchial cavity. The pallial openings arise approximately between, and just at the base of, the 2nd and 3rd pair of arms, and extend to between the 3rd and 4th pairs. The integument of the mantle seems in parts tough and fibrous, and there is a suggestion also of faint minute pustulation.

Colour.—Uniform dingy-yellow, with scattered small brown chromatophores.

Measurements.—Posterior end of body to eye pupils, 4 mm.; eyes to longest arm tip, 8 mm. Total length, 12 mm. Width of body, 5 mm. Total length of type is 45 mm., and of a Japanese species 135 mm. (Sasaki).

Locality.—Station 18A/38. 24/10/38. N.100. Hor. 42°35′S., 148°37′E. (near Maria Island, E. Tasmania). Slope. One specimen.

Remarks.—This little species is obviously the same as Hoyle's type, and provides the first record for Tasmanian waters, thus bringing its range still further south.

Indeterminable Larval Cephalopods.

A small number of minute specimens were not in a condition for determination, other than as cephalopods.

Cephalopod Egg.

A minute, gelatinous rounded cephalopod egg, 2 mm. in diameter, from Station 132/39. 5/5/39. N.70. Hor. 30°15′S., 153°33′E. (near Coffs Harbour, N.S.W.). Slope, showed a larval Decembrachiate cephalopod emerging head first through a break towards one edge (fig. 24).

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EXPLANATION OF PLATES XXIV-XXVII.

PLATE XXIV.

Fig. 1.—*Abralia ? astrosticta* Berry. Dorsal view. Station 201/39. 17/7/39.
Fig. 2.—*Abralia ? astrosticta* Berry. Ventral view. Station 201/39. 17/7/39.
Fig. 3.—*Abralia ? astrosticta* Berry. Portion of arm, with magnified spine alongside. Same specimen.
Fig. 4.—*Abralia ? astrosticta* Berry. Tentacular club. Same specimen.
Fig. 5.—*Abralia ? astrosticta* Berry. ? larval form (cf. *Asthenoteuthion planctonicum* Pfeffer). Dorsal view. Station 27/40. 21/4/40.
Fig. 6.—*Abralia ? astrosticta* Berry. Ventral view of same specimen.
Fig. 7.—*Abralia ? astrosticta* Berry. Eye of same species from Station 26/40. 20/4/40.
Fig. 8.—*Abralia ? astrosticta* Berry. Funnel of same species from Station 27/40. 21/4/40.
Fig. 9.—*Abralia ? astrosticta* Berry. Gladius of specimen, Station 27/40.
Fig. 10.—*Abralia ? astrosticta* Berry. Tentacular club of same.
Fig. 11.—*Abraliopsis ? hoylei* Pfeffer. Dorsal view. Station 66/38.
Fig. 12.—*Abraliopsis ? hoylei* Pfeffer. Ventral view of same.
Fig. 13.—*Abraliopsis ? hoylei* Pfeffer. Left tentacular club of same.
Fig. 14.—*Abraliopsis ? hoylei* Pfeffer. Portion of arm of same.
Fig. 15.—*Abraliopsis ? hoylei* Pfeffer. Immature specimen. Dorsal view. Station 217/39.
Fig. 16.—*Abraliopsis ? hoylei* Pfeffer. Immature specimen. Ventral view.
Fig. 17.—*Abraliopsis ? hoylei* Pfeffer. Tentacle of same.
Fig. 18.—*Pterygioteuthis giardi* Fischer. Dorsal view. Station 140/39.
Fig. 19.—*Pterygioteuthis giardi* Fischer. Ventral view. Station 140/39.
Fig. 20.—*Pterygioteuthis giardi* Fischer. Third arm, back view. Station 140/39.

PLATE XXV.

Fig. 1.—*Tetronychoteuthis massyae* Pfeffer. Dorsal view. Station 17/38.
Fig. 2.—*Tetronychoteuthis massyae* Pfeffer. Ventral view, head and arms.
Fig. 3.—*Tetronychoteuthis massyae* Pfeffer. A sucker from a tentacle.
Fig. 4.—*Tetronychoteuthis massyae* Pfeffer. Portion of integument of same specimen, showing pustules.
Fig. 5.—*Tetronychoteuthis massyae* Pfeffer. Pustules enlarged.
Fig. 6.—*Onychoteuthis rutilus* Gould. Dorsal view. Station 127/39.
Fig. 7.—*Onychoteuthis rutilus Gould.* Ventral view. Station 127/39.
Fig. 8.—*Onychoteuthis rutilus* Gould. Side view. Station 127/39.
Fig. 9.—*Onychoteuthis rutilus* Gould. Dorsal view. Station 60/38.
Fig. 10.—*Onychoteuthis rutilus* Gould. Section of integument. Station 60/38.
Fig. 11.—*Onychoteuthis rutilus* Gould. Siphonal groove of same specimen. Station 60/38.
Fig. 12.—*Calliteuthis miranda* Berry. Ventral view. Station 65/38.
Fig. 13.—*Calliteuthis miranda* Berry. Dorsal view. Station 65/38.
Fig. 14.—*Calliteuthis miranda* Berry. Dorsal view. Station 60/38.
Fig. 15.—*Calliteuthis miranda* Berry. Ventral view. Station 60/38.
Fig. 16.—*Ctenopteryx sicula* Rüppell (Verany). Dorsal view. Station 266/39.
Fig. 17.—*Ctenopteryx sicula* Rüppell (Verany). Ventral view. Station 266/39.
Fig. 18.—*Bathothauma lyromma* Chun. Dorsal view. Station 22A/38.
Fig. 19.—*Idiosepius notoides* Berry. Ventral view of head and arms. Station 188/39.
Fig. 20.—*Idiosepius notoides* Berry. Dorsal view of whole animal. Station 188/39.

PLATE XXVI.

Fig. 1.—*Nototodarus gouldi* (McCoy). Ventral view. Station 73/38.
Fig. 2.—*Nototodarus gouldi* (McCoy). Siphonal groove. Station 73/38.
Fig. 3.—*Nototodarus gouldi* (McCoy). Fused tentacular arms of *Rhyncoteuthion* larval form. Station 31/40.
Fig. 4.—*Nototodarus gouldi* (McCoy). Dorsal view of more mature specimen. Station 31/40.
Fig. 5.—*Nototodarus gouldi* (McCoy). Ventral view of head and arms of same, showing tentacles united only at clubs. Station 31/40.
Fig. 6.—*Nototodarus gouldi* (McCoy). *Rhyncoteuthion* larval form. Dorsal head. Station 28/40.
Fig. 7.—*Nototodarus gouldi* (McCoy). *Rhyncoteuthion* larval form. Ventral view of same.
Fig. 8.—*Nototodarus gouldi* (McCoy). *Rhyncoteuthion* larval form. Dorsal head. Station 24/40.
Fig. 9.—*Nototodarus gouldi* (McCoy). *Rhyncoteuthion* larval form. Ventral head. Station 40/38.
Fig. 10.—*Nototodarus gouldi* (McCoy). *Rhyncoteuthion* larval form. Ventral view of fused tentacles. Station 141/39.
Fig. 11.—*Nototodarus gouldi* (McCoy). *Rhyncoteuthion* larval form. Ventral head. Station 193/39.

Fig. 12.—*Nototodarus gouldi* (McCoy). *Rhyncoteuthion* larval form. Dorsal view. Station 47/38.

Fig. 13.—*Nototodarus gouldi* (McCoy). *Rhyncoteuthion* larval form. Ventral view. Station 24/40.

Fig. 14.—*Nototodarus gouldi* (McCoy). *Rhyncoteuthion* larval form. Side view. Station 134/39.

Fig. 15.—*Brachioteuthis riisei* (Steenstrup). Dorsal view. Station 255/39.

Fig. 16.—*Brachioteuthis riisei* (Steenstrup). Ventral view. Station 255/39.

Fig. 17.—*Brachioteuthis riisei* (Steenstrup). Tentacle club. Station 255/39.

Fig. 18.—*Mastigoteuthis grimaldii* (Joubin). Dorsal view. Station 17/38.

Fig. 19.—*Mastigoteuthis grimaldii* (Joubin). Ventral view. Station 17/38.

Fig. 20.—*Mastigoteuthis grimaldii* (Joubin). Portion of left ventral arm of same specimen.

Fig. 21.—*Mastigoteuthis grimaldii* (Joubin). Buccal area of same specimen.

Fig. 22.—*Eledonella sheardi* sp. nov. Dorsal view. Station 219/39.

Fig. 23.—*Eledonella sheardi* sp. nov. Ventral view. Station 219/39.

Fig. 24.—*Eledonella sheardi* sp. nov. Third and fourth right arms of same specimen.

Fig. 25.—*Eledonella sheardi* sp. nov. Front view of funnel of same specimen.

Fig. 26.—*Eledonella sheardi* sp. nov. Side view of funnel.

Fig. 27.—*Eledonella sheardi* sp. nov. Right eye.

Plate XXVII.

Fig. 1.—*Megalocranchia pardus* Berry. Ventral view. Station 217/39.

Fig. 2.—*Megalocranchia pardus* Berry. Dorsal view head and arms. Station 217/39.

Fig. 3.—*Megalocranchia pardus* Berry. Tentacle of same.

Fig. 4.—*Megalocranchia pardus* Berry. Head and arms of larger specimen. Station 63/38.

Fig. 5.—*Pyrgopsis pacificus* (Issel). Dorsal view. Station 62/38.

Fig. 6.—*Pyrgopsis pacificus* (Issel). Ventral view. Station 62/38.

Fig. 7.—*Pyrgopsis pacificus* (Issel). Tentacle club. Station 62/38.

Fig. 8.—*Pyrgopsis pacificus* (Issel). Portion of arm. Station 62/38.

Fig. 9.—*Pyrgopsis pacificus* (Issel). Some tubercles of the cartilaginous ridge on ventral surface.

Fig. 10.—*Pyrgopsis pacificus* (Issel). Side view of same. Magnified.

Fig. 11.—*Pyrgopsis pacificus* (Issel). Gladius of specimen from 62/38.

Fig. 12.—*Amphitretus pelagicus* Hoyle. Dorsal view. Station 18A/38.

Fig. 13.—*Amphitretus pelagicus* Hoyle. Ventral view. Station 18A/38.

Fig. 14.—*Amphitretus pelagicus* Hoyle. Side view of pallial opening. Station 18A/38.

Fig. 15.—*Octopus pallida* Hoyle. Dorsal view. Station 43/38.

Fig. 16.—*Octopus pallida* Hoyle. Ventral view. Station 43/38.

Fig. 17.—*Octopus pallida* Hoyle. Dorsal view. Station 60/38.

Fig. 18.—*Octopus pallida* Hoyle. Arm, side view. Station 96/38.

Fig. 19.—*Octopus tetricus* Gould. Dorsal view. Station 104/39.

Fig. 20.—*Euprymna tasmanica* Pfeffer. Dorsal view. Station 184/39.

Fig. 21.—*Euprymna tasmanica* Pfeffer. Ventral view. Station 184/39.

Fig. 22.—*Heteroteuthis serventyi* sp. nov. Dorsal view. Station 66/38.

Fig. 23.—*Heteroteuthis serventyi* sp. nov. Side view. Station 66/38.

Fig. 24.—Larval cephalopod emerging from egg. Station 132/39.

Fig. 25.—*Brachioteuthis riisei* (Steenstrup). Side view of very young specimen showing large ventral arm. Station 224/39.

Joyce Allan, *del.*

A SIMPLIFIED KEY TO THE SESSILE BARNACLES FOUND ON THE ROCKS, BOATS, WHARF PILES AND OTHER INSTALLATIONS IN PORT JACKSON AND ADJACENT WATERS.

By Elizabeth C. Pope, M.Sc.,
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(Plates xxviii–xxx; Figures 1–5.)

Introduction.

It is generally considered by dock authorities that the fouling of ship bottoms by barnacles in the harbour of Sydney, Port Jackson, is heavy in comparison with other localities. Unlike most other organisms which attach themselves to the bottoms of ships, barnacle shells do not necessarily drop off or decay away once the organism in them dies, and docking and scraping are necessary to remove them effectively. This is an expensive process and consequently much attention is being given to the production of anti-fouling substances for use on harbour installations. Actually it is possible that a coating consisting of thousands of barnacles on a wharf pile or other wooden structure under water may itself, by the constant feeding of the individuals, cause considerable reduction in the numbers of swimming larvae of such undesirable wood-borers as the shipworm or Cobra (Teredinine borers).

Much work remains to be done in connection with both these problems, and it has become a primary necessity for the field worker to be able to distinguish quickly and easily the different species of barnacles found in the waters of Port Jackson. The various monographs and scientific papers dealing with this group of crustaceans are not as a rule easy of access to the workers on these problems and often contain unnecessarily detailed descriptions of the various species. This simple key has therefore been drawn up to help these workers. The author has assumed that some of the users of this key will be unfamiliar with the zoological terms usually applied to the various parts of the body and shells of these animals. Accordingly, as few of these technical terms as possible have been introduced, and differences in field occurrence and external structure will be used, as far as may be, to distinguish between one species and another, rather than the very necessary finer points of anatomical difference used by the specialists in this group. Workers desirous of more complete and detailed descriptions should refer to Darwin's monograph (1854) on this group or some other later standard work of that nature.

Relationships and Anatomy of the Barnacles.

In spite of their appearance, barnacles are not molluscs like mussels or oysters, but are close relatives of the prawns, crabs and other crustaceans. They have been aptly described by Huxley as shrimp-like animals which have become attached by their head ends to some submerged object and then have proceeded to construct round their bodies cases of armour-like plates. These plates butt one against the next and serve as a protection for the soft parts of the body. The technical name for the barnacles is Cirripedia, bestowed on them because of their feathery, cirrus-like feet which are protruded through a gap between parts of the hard shelly coat when the animal is feeding. These feathery feet are used to "comb" the barnacles' food-particles from the surrounding water.

Of the barnacles encountered on the rocky foreshores and installations of Port Jackson, two distinct kinds may easily be recognized: the stalked or "Goose" barnacles and the sessile or "Acorn" barnacles. In the stalked ones the body is protected by an outer covering of plates and the animal has a stalk or peduncle, sometimes several inches in length. In the sessile type there is no stalk, and the soft parts of the animal which are surrounded by a roughly cone-shaped wall of plates, grow directly attached to objects such as stones, piling, ships' bottoms or the shells of other animals. The stalked barnacles are mainly creatures of the ocean waters, while the acorn barnacles are commonest along the shores and shallow seas. It is with the latter group that this paper is concerned.

The barnacle reveals its real nature and its close affinity with other crustaceans in its life-history because the young leave the parent as the typical free-swimming crustacean larva called a nauplius. In this stage the young may be scattered far from their place of origin by currents. As the young larva grows, it undergoes several moults and changes its appearance radically, growing a two-piece shell and resembling another small crustacean type, the Ostracod *Cypris*, very closely in appearance. For this reason the young barnacle at this stage of its development is called the cypris stage.

The cypris stage swims about in the sea and seeks out a spot suitable for attaching itself. It does this by means of an adhesive cement poured out by a gland situated towards the head end of the body. After this stage, all the limbs of the adult are present. The bivalved shell remains until the barnacle is attached and then is cast off and the plates of the adult shell begin to grow, being laid down by an outer covering of the body.

In order to determine the genus of a barnacle it is necessary to be able to orientate and know the names of some parts of the shell and body.

The shell consists of a *basis* and a circular wall made up of 4, 6 or 8 main *plates*. These abut one against the next to make the solid outer coat of the animal. The basis is closely applied to the substratum on which the barnacle is growing and may be flat or cup-like and *calcareous* or *membranous*. Where the basis is calcareous it may be solid, or may have a series of radiating channels in it, called pores. The plates of the shell are separated from one another by *sutures* which can be quite distinct or may be obliterated as the barnacle matures and grows old.

At the upper or free end of the shell is the opening to the outside world, the *orifice*, the shape of which is often an aid in the determination of the species. The orifice is closed by a lid-like structure, the *operculum*, which is joined to the wall-like

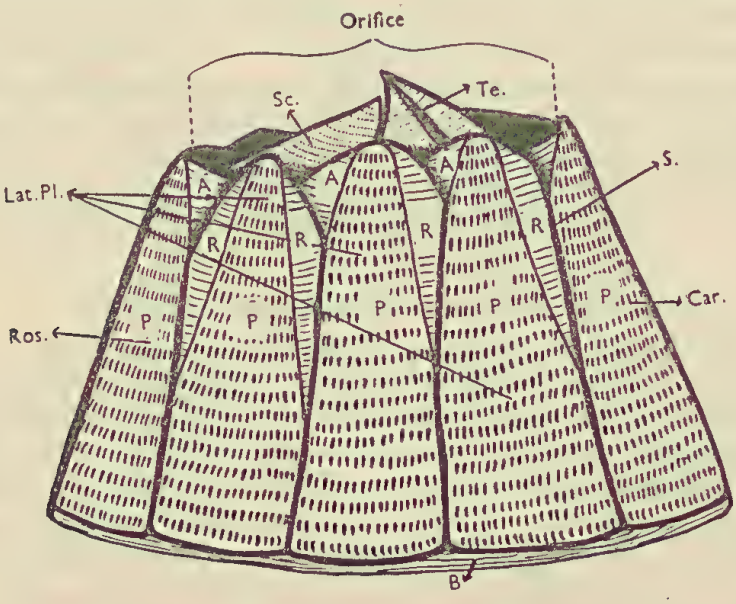

Figure 1.—Diagram of the whole shell of a barnacle. A., alae; B., basis; Car., carina; Lat. Pl., lateral plates; P., parietes; R., radius; Ros., rostrum; S., suture; Sc., scutum; Te., tergum.

part of the shell by a chitinous *opercular membrane*. The operculum is made up of two pairs of small shells or valves known as the *scuta* and *terga* and between them is a slit-like opening which leads into the sac inside the shell, where the soft body-parts lie. It is through this slit that the feathery cirri are poked when the animal feeds (Figs. 1, 2).

The structure of the opercular valves is of the utmost importance as an aid to the identification of barnacle species and should always be taken into account when checking field identifications. A low-powered microscope is generally necessary for viewing these valves, but in the larger species a hand lens may be sufficient (Figs. 3, 4).

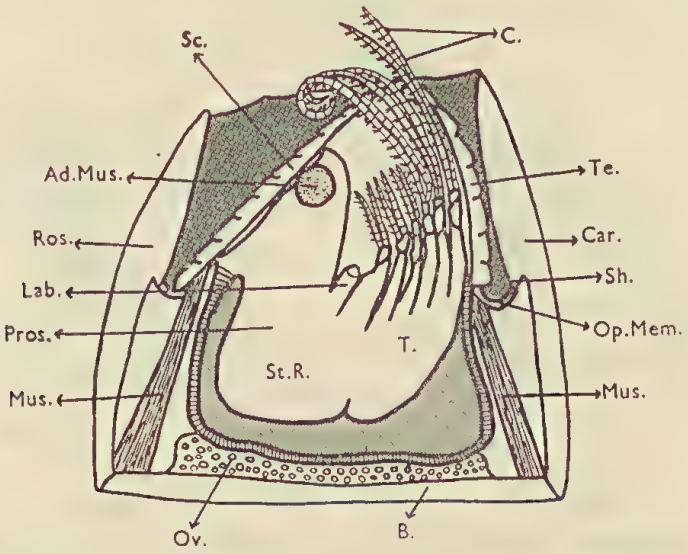

Figure 2.—Diagram of barnacle with part of shell removed to display soft parts. Ad. Mus., adductor muscle cut end; B., basis; C., cirri; Car., carina; Lab., labrum; Mus., muscle; Op. Mem., opercular membrane; Ov., ovary; Pros., prosoma; Ros., rostrum; Sc., scutum; Sh., tip of sheath; St. R., region of stomach; T., thorax; Te., tergum.

Each plate of the shell, apart from the opercular valves, consists of a central, triangular-shaped section, the *paries* (plural *parietes*) with, as a rule, two side parts called either radii or alae according to whether they overlap or underlie the side parts of the adjacent plate. Side pieces which overlap the next plate are called *radii*, and those which underlie them are called *alae*. A plate may have alae on either side of the central portion or radii, or one radius and one ala. (See Fig. 1.)

Examination of the basal end of a shell-plate of a barnacle such as *Tetraclita rosea* shows that the walls are not always simple, single-layered structures. Generally there is an outer and an inner *lamina* across which run strengthening *septa* dividing the walls into a series of tubes or *pores*. Further branchings of the septa may lead to the formation of more than one row of pores between the outer and the inner lamina of each shell-plate. Such a state of affairs is found in *Tetraclita purpurascens* (Plate xxix, fig. 3).

The various plates in the shell have names, and since the genus is generally decided by the arrangement of these shell parts it is necessary to know some of them. The most primitive type of acorn barnacle found today is the genus *Catophragmus*, and its shell is made up of eight main plates with numerous whorls of smaller ones outside. But in most other genera there has been a reduction in the number of main plates to six or four, and the outer whorls of small plates or scales are absent altogether. This reduction in the number has been brought about by fusion of some of the plates. Such a fusion during the development from juvenile to adult form of an individual has been observed and described by Miss Lucy B. Moore (1944) in the barnacle *Chamaesipho brunnea*, where the juvenile definitely has six plates and the adult four.

The plate situated at the end of the shell where the cirri are poked out (the end of the shell where the tergal opercular valves are) is called the *carina*. This plate always

has two alae and is, therefore, overlapped by adjacent plates. The plate in the shell directly opposite to the carina is the *rostrum*. In more primitive types of barnacles it also has two alae like the carina, and should the shell-pieces of such a barnacle become detached it is then difficult to distinguish the carina from the rostrum. Usually, however, the carina is more bent than the rostrum of the same species and in this way can be distinguished. Between the carina and the rostrum lie the lateral plates ranging from three pairs to one pair in number. It is not necessary for the purposes of this paper to know their names, but in determining the genus it is necessary to know their arrangement and to know whether they overlap or underlie the plates on either side. A rough cross-sectional diagram of the arrangement of the plates in the upper part of the shell should be made for comparison with those in Figure 5.

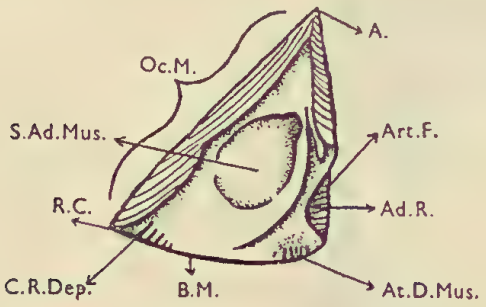

Figure 3.

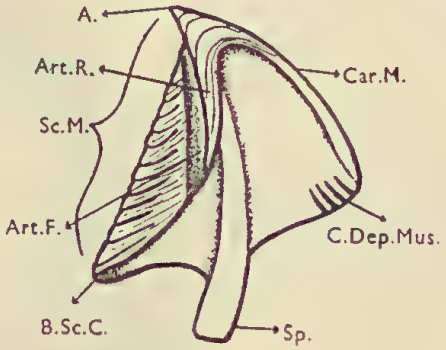

Figure 4.

Figure 3.—Scutum, inside view. A., apex; Ad. R., adductor ridge; At. D. Mus., Attachment of depressor muscle; Art. F., articular furrow; B.M., basal margin; C.R. Dep., crests for rostral depressor; Oc. M., occludent margin; S. Ad. Mus., scar of adductor muscle; R.C., rostral corner.

Figure 4.—Tergum, inside view. A., apex or beak; Art. F., articular furrow; Art. R., articular ridge; B.Sc.C., basi-scutal corner; Car. M., carinal margin; C. Dep. Mus., crests for depressor muscle; Sc. M., scutal margin; Sp., spur.

If part of the shell be removed, so that the soft body of the barnacle is displayed, the six posterior thoracic segments of the body may easily be recognized because they bear the feathery cirri. In front of them is a large swollen-looking portion called the *prosoma* which houses the stomach region of the barnacle. There is no abdomen comparable with that found in other crustaceans (Fig. 2).

The mouth is situated in front of the base of the first pair of cirri and is furnished with a prominent upper lip or *labrum* and four pairs of jaws. The finer structural differences of some of these are used as criteria for identifications by specialists.

The condition of the eggs in the ovaries may easily be observed, for the eggs lie at the base of the sac and are easy of access.

Determination of the Family.

As a first step towards identification, the barnacle should be orientated so that the carinal and rostral plates are known. A note should be made whether the rostrum has two radii or two alae, as this determines the family to which the barnacle belongs. Use of Figure 5 will help to determine the genus of the barnacle. Subsequent use of the keys for the species of each genus will then determine any of the more common Sydney species likely to be encountered on harbour rocks and installations.

Confirmation of the family to which the barnacle belongs can be made by making an examination of the labrum. In one family, the Balanidae, there is always a central notch in the labrum, whereas in the family Chthamalidae there is a concave edge to the labrum, but it is not sharply notched as in the previous family (Figure 5). While it is not generally necessary to resort to the use of this latter character for family

identifications, it can become exceedingly useful where the shelly parts have been eroded or the sutures have become obliterated with age or by encrusting growths.

If the rostrum of the barnacle has two alae and the labrum has a concave edge, not sharply notched in the centre, then it is a member of the family Chthamalidae and the ground plan of the arrangement of the plates should be found among those in the upper row in Figure 5. If, on the contrary, the barnacle has a rostrum with two radii and the labrum is notched in the centre, then the ground plan of the plates of the shell should be found among the members of the family Balanidae in the lower row in Figure 5.

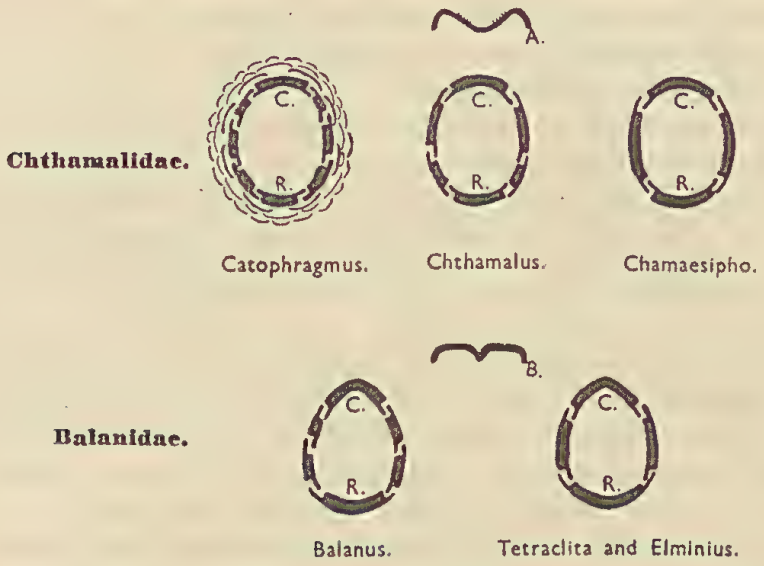

Figure 5.—Scheme showing arrangement of plates and structure of labrum in each family. Outline of anterior border of labrum in (A) Chthamalidae and (B) Balanidae.

Family Chthamalidae.

This family is represented by only three species in the Sydney district and all belong to different genera. Since each of these has a different number of plates in the shell, they are easy to distinguish one from the other.

All of them agree in having the rostral plate with alae, the walls of the plates never have pores, and the upper lip or labrum is not notched, being merely concave in the centre (Figure 5).

None of the members of this family appears to be concerned in the fouling of timber harbour-works since they are always found attached to littoral rocks, generally in spots exposed to a considerable amount of water movement.

In this family is found the primitive genus *Catophragmus*. In the shell are eight principal plates surrounded by several additional outer whorls of very much smaller plates or scales and these make the genus easy to distinguish. The genus *Chthamalus* has a shell composed of six plates, while the remaining genus, *Chamaesipho*, has only four plates often so fused together that no sutures can be distinguished. Sometimes boiling in a weak solution of caustic potash or soap will loosen the shell-plates by destroying the animal matter which holds them together.

Key to Genera and Species of the Chthamalid Barnacles.

A. Chthamalidae with eight plates round the orifice and additional outer whorls of small scales. Typical specimens three-quarters of an inch in basal diameter .... *Catophragmus polymerus*

AA. Chthamalidae with less than eight plates round the orifice.

1. Shell with six plates. Typical specimens half an inch basal diameter .... *Chthamalus antennatus*

2. Shell with four plates often so fused together that no sutures can be seen. Typical specimen one-quarter of an inch in basal diameter ..... *Chamaesipho columna*

Catophragmus (Catomerus) polymerus Darwin.

(Plate xxviii, fig. 1; and Plate xxx, figs. 1–2.)

Appearance.—This barnacle has a most characteristic structure and may be identified by the outer whorls of plates or scales which surround the eight principal ones making up the wall. Each of these small scales overlies the suture between two adjacent plates of the row immediately inside it. The scales increase in number but decrease in size in the outer whorls. On occasions, when a specimen is so eroded that the relationships of the radii and alae of the principal plates cannot be seen, these additional whorls make identification simple.

Size.—Large specimens may grow till the basal diameter is about one and a quarter inches, but slightly less than one inch is the typical size.

Basis.—The basis is thin and membranous.

Colour.—The general colour of the plates is grey-green, but the shell is sometimes coated with a hairy, brown-coloured alga.

Opercular Valves.—The scuta bear prominent articular ridges with deep furrows above and below, into which fit corresponding ridges on the tergum. The tergum has a most marked articular furrow and the crests for the attachment of the depressor muscles extend half-way across the basal margin of the valve. There is no true spur.

Habitat.—*Catophragmus* is popularly known as the Surf Barnacle, since its requirements seem to be a moderately high position, above low water mark, near the seaward edge of a rocky headland. Here, though it is out of water for some hours during the low tide, it is nevertheless bathed in spray and kept moist all the time.

Best developed colonies of *Catophragmus* are found on almost vertical rock faces, exposed to the surf, at the outer edges of rock platforms. In such positions they may grow so closely as to form an almost continuous, frieze-like band several feet high. Normally such a 'frieze' is found above the level of the reef where *Balanus nigrescens* grows and below the spots chosen by *Tetraclita rosea*, but on flatter rock platforms these three species may all be found growing together at the one level, and extending a considerable way up into the tidal area.

Localities.—Newport; Long Reef; North Head, Port Jackson; Middle Head, Port Jackson; Hunter's Beach, Port Jackson; Bondi; Maroubra.

Remarks.—Near Port Jackson *Catophragmus* is found chiefly on the open coast and not to any great extent in the harbour itself. It is, therefore, not an organism which fouls harbour installations.

The genus *Catophragmus* has been divided into three sub-genera and the local species belongs to the sub-genus *Catomerus.*

Chthamalus antennatus Darwin.

(Plate xxviii, fig. 4; and Plate xxx, figs. 3–4.)

Appearance.—*Chthamalus antennatus* is a small barnacle with a very strong shell, generally shaped like a flattened cone. The outer surfaces of the shell-plates are often rugged and corroded (more rarely quite smooth). The sutures between the plates are very clearly marked and the orifice is small, elongated, and sub-rhomboidal, with two shorter sides (the broader part of the orifice) towards the carinal end of the shell.

Size.—Large specimens are generally little more than half an inch in basal diameter and typical ones are slightly smaller.

Basis.—The basis is membranous and black and, since the barnacle adheres very closely to the substratum, the roughened edges of the plates often give a wavy outline to it.

Colour.—The colour of the shell is generally a light dirty-grey with pale green or brown overlying it according to the state of erosion. Internally the shell is lined by a black membrane which retains its colour even after preservation.

Opercular Valves.—The scutal valves are long and narrow and there is a small but deep depression for the attachment of the adductor muscle. There is also a prominent articular ridge which fits into a correspondingly deep notch on the tergum. The tergum

is small (about half the size of the scutum) and has no spur, but possesses a few pronounced crests for the attachment of the depressor muscles near the basi-carinal corner of the valve. Worn and eroded specimens often show this deep locking together of the opercular valves.

Habitat.—C. antennatus grows on rocks or the shells of molluscs living at a high level in the inter-tidal part of the shore. In fact, it manages to live on rocks which are only submerged during high spring tides and feeding can only take place at these times. The rest of the time the barnacle obtains its moisture requirements from the spray in the air and opens its opercular valves only in the cooler parts of the day or during the night. The necessity for continual moistening of spray, together with its intolerance of mud, limits the distribution of this species to parts of the Port near the outlet to the sea.

Ouside the Port, on the open coast *C. antennatus* is more plentiful on the higher parts of the rocky headlands than it is inside. In the latter place the barnacle is found at a slightly lower position on the rocks, probably owing to the lack of spray in the air.

Localities.—On rocks at Newport; Long Reef; Harbord; Maroubra; Hunter's Beach, Port Jackson; Bottle and Glass Rocks, Vaucluse, Port Jackson; Rose Bay, Port Jackson; Northbridge Headland, Middle Harbour; The Spit, Middle Harbour; Middle Head, Port Jackson.

Remarks.—Since *C. antennatus* prefers to attach itself to rock or other stone-like substrata and since it does not extend far into the waters of the harbour, it causes no trouble as a fouling organism in the Port.

Chamaesipho columna (Spengler).

(Plate xxviii, fig. 2–3; and Plate xxx, figs. 5–6.)

Appearance.—In single specimens of this barnacle the shell is low and conical, but, as a rule, a great many individuals grow so close together that they have to adopt a columnar shape. Often they become fused into sheets and look like honeycomb. So fused do the barnacles become that it is often impossible to tell where the plates of one end and the next begin.

There are four plates in the shell, which are so completely fused together in the adult that it is impossible to see the sutures between them from the outside and sometimes they are obliterated internally. Even maceration in boiling soap solution may fail to disclose the joints between plates. The orifice is comparatively large and sub-rhomboidal in shape, having the broader end towards the carinal part of the shell. In the crowded columnar sheets, the individuals appear much eroded and worn, and the scuta and terga may be firmly locked together by a deep ridge and notch.

Basis.—The basis is membranous and the bottom of the shell has a wavy, irregular outline.

Colour.—The colour is greyish-white, but the eroded tops of 'honeycomb' specimens may be a dirty brown or green, or flesh colour. The outer cover of the soft parts of the body is a dark navy blue verging towards brown and this colour persists in preserved and dried specimens.

Opercular Valves.—The shapes of the opercular valves are rather variable, but the scutum always has a wide articular furrow and a marked ridge for locking into the tergum. There is a very deep little pit for the attachment of the adductor muscle. The tergum is a small valve with no spur, and a deep articular furrow for the reception of the ridge of the scutum bites deeply into it. There are several small pits where the depressor muscles are attached.

Habitat.—Chamaesipho is found on the rocky shores of the coast outside and just inside the mouth of the Port. It favours the half-tide area of the rocks, occurring above *Tetraclita rosea*, but below *Chthamalus antennatus*. It does not grow on woody substrata, but is sometimes found attached to limpets or other fairly 'fixed' molluscs (see Pl. xxviii, fig. 3).

Localities.—Newport; Long Reef; Harbord; Cronulla; Middle Head, Port Jackson; Bottle and Glass Rocks, Vaucluse, Port Jackson; Rose Bay, Port Jackson; North Harbour, Port Jackson.

Remarks.—This species is easily the most abundant of the inter-tidal barnacles for it encrusts the rocks literally in millions in the half-tide area.

Although it is so prolific on rocks outside and near the mouth of the harbour, *C. columna*, because it grows mainly on rocks or stone-like substrata, is not a significant fouling organism on harbour installations.

Family Balanidae.

Representatives of three genera of this family are commonly found on harbour installations and rocks in the Port Jackson district, and of these, members of the genus *Balanus* cause most trouble. One species of the genus *Elminius* grows prolifically on all kinds of substrata near the upper limits of the tidal range and the genus *Tetraclita* is also represented among the organisms fouling harbour works.

One other genus of this family, *Acasta*, is occasionally found in sponges growing on piles and rocks, but, since it does not grow directly on the surface of these substrata and cannot, therefore, be reckoned as a true fouling organism, it is not dealt with here.

All the members of this family agree in having a rostrum with two radii, a labrum distinctly notched in the centre (Figure 5), and all of the lateral shell-plates have a radius on one side and an ala on the other.

The shell of the genus *Balanus* is made up of six plates, while the genera *Elminius* and *Tetraclita* each have four. However, these two latter are easily separated from one another because in *Elminius* the walls of the parietes of the plates are not porose, whereas in *Tetraclita* large prominent pores may be seen. *Elminius* has a southern distribution, whereas *Tetraclita* has a more tropical one.

Key to the Genera of Balanid Barnacles.

A. Balanidae in which the shell is composed of 6 plates ..... *Balanus*
AA. Balanidae in which the shell is composed of 4 plates.
1. Parietes of plates porose ..... *Tetraclita*
2. Parietes of plates not porose ..... *Elminius*

Genus Balanus.

The genus *Balanus* comprises members of the family Balanidae which have six plates in their shells. As a rule, the upper part of the inside of each of the plate walls is thickened, and these thickened upper portions together with the alae form a ring or *sheath* round the inside of the shell. It is to the bottom of this sheath that the membrane which joins the opercular valves to the rest of the shell is attached. The bases of the local species are all calcareous, though in the case of *B. imperator* it is a very thin layer and is not permeated by radiating pores, being formed rather by a mosaic of tiny calcareous beadlets.

In some of the species of the genus *Balanus* the lateral edges of the radii bear transverse ridges or *septa* which are toothed. These dovetail with corresponding grooves on the outside surfaces of the alae of the adjacent plates. In the species *B. nigrescens* the radii are pierced by pores which open between the septa and run perpendicular to those in the parietes. The course followed by the pores in this species may generally be seen, for they appear on the outside surface of the radii as black, transverse lines where the outer lamina of the radius is eroded away.

Five species belonging to this genus occur commonly in the Port of Sydney and environs. Of these, three types are found fouling boats and harbour installations. They are *B. amphitrite* var. *communis*, *B. amphitrite* var. *cirratus* and *B. trigonus*. *B. amaryllis* might be expected to be a fouling organism, but has not, as yet, been revealed as such here.

The two remaining local species of the genus are *B. nigrescens* and *B. imperator*, both of which attach themselves to rock or occasionally to mollusc shells, and they frequent the rocky shores near the mouth of the Port or the open coast. *B. nigrescens*

grows to the largest size among the local barnacles and seems to prefer positions where the salinity is high and where there is plenty of water movement—preferably surf. It attaches itself solidly to rocks near the low water mark, growing to a steeply conical shape and often becoming much corroded and overgrown by coralline algae, and limpets and other small animals attach themselves to the outside of the shells.

B. imperator, on the other hand, seems to prefer a slightly more sheltered situation than *B. nigrescens*, for on the open coast it is found chiefly in more sheltered crannies in the rocks or under boulders, while in the Port, in places where *B. nigrescens* grows very sparsely on the rocks, *B. imperator* becomes the dominant low-water-mark barnacle on the upper surfaces of the rocks and may occur in thousands. Such a condition may easily be seen on the rocks near Vaucluse Bay, near the mouth of Port Jackson.

Of the three chief fouling species, *B. amphitrite*, occurring in two varieties, is the one most frequently found on those parts of wharf piles which are exposed during low tides and on the bottoms of floating craft. It seems to attach itself indiscriminately to any substratum, and is found on almost every one of the test samples of timber which are submerged at various points in the Port by the Preservation and Research Laboratory of the Maritime Services Board of New South Wales. The majority of these samples are suspended so that they extend from two feet above zero tide mark down to three feet below this point.[1] On these samples *B. amphitrite* var. *cirratus* often grows in a very crowded manner and takes on an irregular tubular shape, whereas on the bottoms of small craft or in other places where it is not crowded it generally grows to a more conical shape. These differences in shape are shown in Plate xxviii, fig. 6. In forms with the tubular type of growth the orifice is comparatively larger and, in general, is more distinctly toothed than in the more cone-like forms. The change in shape is chiefly brought about by the change in the form of the basis. In cone-like forms the basis is flattish, whereas in tubular forms the basis is deep and cup-shaped.

The two varieties found are var. *cirratus* and less commonly var. *communis*. Often the two varieties occur side by side on one substratum, but whereas *B. amphitrite* var. *cirratus* often grows to a tubular shape, in the author's experience var. *communis* is generally much more the conventional depressed cone-shape. *B. amphitrite* seems to occur from the tidal range down to 50 feet below low water mark, and there has been no opportunity so far of checking its occurrence in depths below this point.

Balanus trigonus, the second of the species which foul boats and harbour structures, does not appear to extend its range up into the tidal area as frequently as does *B. amphitrite*. It is found chiefly on the shells of moluscs (mussels) which grow on buoys or the bottoms of boats, and it is also taken on timber such as the bottom sections of wharf piles or the specially long wooden test samples set 50 feet below low water mark by the Preservation and Research Laboratory of the Maritime Services Board. In the collections of the Australian Museum there are many dredged specimens of this species from slightly deeper waters both inside and outside the Port, and this would lead one to believe that it is a deeper water form. Although the bathymetrical range of this species overlaps that of *B. amphitrite* so that the two forms occur together, and although they belong to the one sub-genus of the genus (*Balanus*), they may be distinguished quite easily one from the other by an examination of the outer surfaces of the scutal valves. In *B. trigonus* there is a regular arrangement of deep little pits on the scutum. These occur in from one to six longitudinal rows and are formed because there are deep longitudinal furrows crossed (more or less at right angles) by very prominent lines of growth or transverse ridges. Sometimes the pits may be filled up by sediment, but a light brushing with a toothbrush will disclose their presence. In *B. amphitrite* the scutum is generally very smooth. There is usually also a basic difference between the shapes of the orifices in these two species. In *B. trigonus* it is sub-triangular in shape (nearly equilateral) and is not markedly toothed. In *B.*

[1] The height of the tide is measured in the Port of Sydney from an arbitrarily chosen zero mark on the official tide gauge at Fort Denison. This mark approximates to the average level of the low water mark for ordinary low spring tides.

amphitrite the orifice is in general markedly toothed and varies in shape from the more usual rhomboidal to a rounded triangular one.

B. amaryllis, the remaining member of the genus which may foul structures in the Port, is a deeper water form. All the local specimens of this species examined have solid walls in their parietes, with no pores in them and the colour of the outside of the plates of the shell is an even rosy-pink. The orifice is roughly rhomboidal in shape, deeply toothed, and comparatively large in size. The shell of the barnacle may be steeply conical in shape or tubulo-conical. One prominent distinguishing feature may be observed on the scutum which is striated longitudinally so that the prominent lines of growth are divided thereby into small squarish sections. This barnacle may grow to a relatively large size with a basal diameter of more than an inch and a half. Again, as in *B. amphitrite*, the growth of the tubulo-conical form is largely brought about by the cup-shaped growth of the basis.

Key to Species of Balanus.

A. Parietes of shell-plates permeated by pores, radii with edges crenated owing to the presence of transverse septa which are toothed.

1. Very large, steeply conical barnacles (adult specimens are typically 1½-2 inches high; basis 1¼-1½ inches diameter) with radii pierced by pores. In eroded, old specimens the pores may be seen as transverse straight lines on the outer sides of the radii, where the outer lamina has been worn away. In young specimens the pores in the radii are seen to best advantage ..... Sub-genus *Megabalanus*
   Living on rocks near low water mark, in places where considerable water movements take place ..... *B. nigrescens*

2. Smaller species (maximum basal diameter 1 inch; height rarely exceeds more than an inch, generally less) in which the radii are not pierced by pores. Lives generally below low water mark of neap tides and frequently fouls ships and harbour installations ..... Sub-genus *Balanus*

   a. Members of the sub-genus *Balanus* with the parietes with prominent external ribs. General colour pink with the raised ribs white. Orifice triangular (sub-equilateral) and not prominently toothed. Scutum with several longitudinal rows of deep, little pits on the outer surface. Tergum with very blunt, short spur approximately half the width of the valve. Shell always conical or near-conical; not tubular and deep ..... *B. trigonus*

   aa. Members of the sub-genus *Balanus* with the parietes smooth on the outer surface. Colour variable, but purple or purplish-brown predominates when colour is present. Shell may vary from depressed conical to deep tubular shape. Orifice generally deeply toothed and rhomboidal (sometimes rounded trigonal) in outline. Scutum generally rather thin and delicate with prominent lines of growth, often coloured with mauve tinges. There are no longitudinal bands of little pits as in *B. trigonus*. Internally the articular ridge of the scutum is very prominent and recurved. The tergum is very variable in shape and the spur may be either long, narrow and pointed or truncate and short, according to the variety .... *B. amphitrite*

      Variety 1. communis. Shell whitish-grey with longitudinal purple or violet stripes. Radii white, but flecked with red-brown patches. Opercular valves often somewhat eroded exteriorly and more heavily built than in the next variety. Spur of tergum comparatively short, broad and truncated. The bottom of the spur lies parallel to the basal margin of the scutum which is straight on either side of the spur. Shape of shell generally flattened cone type, never tubular in our experience. High water mark neap tide to, at least, 50 feet below low water mark. Grows on almost any type of substratum.

      Variety 2. cirratus. Shell with longitudinal mauve and white stripes intersected by horizontal, purply-brown circular bands which run round the shell. Radii white, occasionally some brown epidermis remains to colour the radii near the parietes. Shape of shell may be either flattened conical or tubular if crowding is taking place. Orifice generally deeply toothed. Scutum thin and delicate with rather

prominent lines of growth. The outer surface of this valve is concave. Tergum with long, narrow, rather sharply pointed spur and the basal margin of the valve slightly hollowed out on either side of the spur.

AA. Parietes solid, not permeated by pores. Radii more or less distinctly developed.

1. Walls of shell-plates a deep, imperial purple colour and comparatively thick. Generally much eroded and encrusted externally by marine growths so that the colour is masked. The colour may be clearly seen on the internal surfaces of the shell, below the sheath. Radii are poorly developed ..... Sub-genus *Austrobalanus*. *B. imperator*

2. Walls of shell-plates thin and a rosy-pink in colour, but not ribbed longitudinally as in *B. trigonus* with which it is often associated in the field. Basis calcareous and permeated by pores. Lower section of parietes ribbed internally below the sheath. Radii with smooth edges, slightly recurved at free edges. Orifice comparatively large and distinctly toothed. Grows in deeper waters—not in tidal range ..... Sub-genus *Chirona*. *B. amaryllis*

Balanus (Megabalanus) nigrescens Lamarck.

(Plate xxviii, fig. 9; and Plate xxx, figs. 7–8.)

Appearance.—A tall and conical barnacle often much corroded and encrusted with marine growths. Orifice smallish and much worn.

Size.—Height one and a half to two inches. Basal diameter one and one-quarter to one and one-half inches.

Basis.—The basis is strong and calcareous and pierced by pores.

Colour.—Greenish-white in young and uneroded specimens. In older ones a dark navy blue or black colour shows through where the outer lamina of the plates is worn away. In living specimens, when the opercular valves are open, a cerulean blue colour may be seen inside the sac at one end.

Opercular Valves.—The opercular valves are often obscured by a growth of algae. The tergum has a beaked or hooked apex, except where it has been eroded away, and this can be used as a weapon of offence. The shapes of the two valves may be seen in Plate xxx, figs, 7, 8.

Habitat.—*B. nigrescens* grows on rocks or shells at low water mark of the spring tides, where there is a good movement of water—preferably surf.

Localities.—Long Reef; Harbord; Newport; Bondi; Cronulla; Watson's Bay, Port Jackson; Balmoral, Port Jackson; Bottle and Glass Rocks, Vaucluse, Port Jackson; Middle Head, Port Jackson; Bradley's Head, Port Jackson.

Remarks.—Since this species grows only on rocks and stone-like substrata, and since it also requires much water movement, it is not a fouling organism in the Port. It is the largest of our local barnacles and is a prominent member of the fauna of the rocks on the open coast.

Balanus (Balanus) trigonus Darwin

(Plate xxix, fig. 6; and Plate xxx, figs. 9–10.)

Appearance.—A moderate-sized barnacle of conical shape with the orifice distinctly triangular in shape and not deeply toothed as in *B. amaryllis* or *B. amphitrite*. The walls of the plates are permeated by pores and on their outsides have distinct raised ribs.

Size.—The height of a typical specimen is from half to three-quarters of an inch. The basal diameter is generally slightly more than three-quarters of an inch, up to one inch.

Basis.—The basis is calcareous, porose and generaly rather flat; hardly ever is a cup-shaped or deep basis seen.

Colour.—The walls of the plates are dark pinkish, with the raised ribs white. The radii are pale pink or white.

Opercular Valves.—Generally only the scutum can be seen through the orifice of a living specimen and, when scrubbed, it shows characteristic longitudinal rows (1–6 in number) of small pits. The tergum is often much worn and has an extremely wide, blunt spur, often half the width of the valve.

Habitat.—This species grows attached to molluscs such as mussels or wood with equal facility. Occasionally it turns up in the tidal area, but, in general, prefers to live below low water mark, and most of the specimens in the collections of the Australian Museum have been dredged, some coming from the deepest parts of the harbour, off Ball's Head in 60 fathoms. It has also been collected off the bottom sections of the wood test samples set by the Preservation and Research Laboratory of the Maritime Services Board at a depth of fifty feet. It is often associated with *Balanus amphitrite* and *B. amaryllis.*

Localities.—Growing on shells and ascidians (*Boltenia* sp.) and kelp at Steele's Point, Vaucluse, Port Jackson; on the foot of piles in Hermit Bay, Port Jackson; dredged off Ball's Head, Port Jackson, on mussels; Bantry Bay, Middle Harbour, on bottom of 50-foot timber test sample; Fort Macquarie picnic jetties, Port Jackson, on piles in tidal area; also dredged at numerous points outside the Port, on the open coast.

Remarks.—This species must be numbered among the fouling organisms in the Port, for it will grow on almost any flat, hard surface that presents itself in deeper waters. It is not, however, as common on small craft as *B. amphitrite. B. trigonus* is generally most strongly attached to the substratum and is difficult to remove properly.

Young specimens make their first appearance on the timber test samples in August, according to Mr. D. Moore, of the Preservation and Research Laboratory of the Maritime Services Board, and within a few months have grown to adult size. Mr. Moore also states that the presence of bark on a test sample inhibits the settling of the cypris young which seem to prefer to attach themselves to cut or sawn surfaces, probably because they are flatter and less rough. In 1915 C. Hedley, in his presidential address to the Royal Society of New South Wales, stated that the pneumatophores of the mangroves are "sometimes loaded with oysters or bristle with barnacles, *Balanus trigonus*". Either conditions of existence have changed very much in the harbour since 1915, when Hedley made this statement, or else the common barnacles of the mangroves were misidentified, for this species is not found in this situation today, *Balanus amphitrite* and *Elminius modestus* being the species found there.

Balanus (Balanus) amphitrite Darwin.
Variety 1. *communis* Darwin.
Variety 2. *cirratus* Darwin.

(Plate xxviii, figs. 5–6; Plate xxix, fig. 6; and Plate xxx, figs. 13–16.)

Appearance.—Moderate-sized barnacles with the shell either conical or tubular, the latter being found in the variety *cirratus* where crowding is taking place. The tubular shape is brought about by a change in the method of the growth of the basis, which is flat or nearly so in conical forms, but is cup-shaped and deep in tubular ones. The orifice is sub-rhomboidal in shape, but is somewhat variable and may even be trigonal. In var. *cirratus* it is generally deeply toothed, whereas in var. *communis* the toothing of the orifice is not nearly so marked. Nevertheless it is much more pronounced in both varieties of *B. amphitrite* than it is in *B. trigonus.* Comparatively the orifice is larger in tubular forms than in conical ones.

The walls of the shell-plates are smooth externally and not ribbed.

Size.—In conical forms the basis of a typical barnacle may be up to three-quarters of an inch in diameter and the height about half an inch. In tubular forms of the var. *cirratus* the height may be an inch and the basal diameter of a typical specimen is about half an inch.

Basis.—The basis is calcareous and pierced by radiating pores. The colour of the basis is white.

Colour.—The colour of the shell differs in the two varieties. Purple, brownish-purple and white are the chief colours present. In the first variety, *communis*, the shell is a whitish-grey with longitudinal purple or violet stripes. Its radii are generally white, flecked with mahogany. In var. *cirratus* the shell has alternate white and mauve stripes which are intersected at right angles by purply-brown circular bands which run round the shell. Under a microscope, these brown bands may be seen to have a wavy

appearance. The radii are generally pale pink or white and the opercular valves are tinged with patches of mauve or purple.

Opercular Valves.—Very often the opercular valves are eroded in var. *communis*, but the uneroded portion of the valve should nevertheless show the prominent lines of growth which are a feature in var. *cirratus*. There are no longitudinal rows of little pits as on the corresponding valve of *B. trigonus*. The terga of the two varieties are somewhat different in shape. In var. *communis* the spur is broad and truncate (Plate xxx, fig. 15), while in var. *cirratus* it is longer, thinner, and pointed (Plate xxx, fig. 14). The basal margins of the two terga also differ, as may be seen by comparing the two figures.

Habitat.—This species appears to have catholic tastes with regard to the substratum chosen, and it may be found growing on wood, including the bark and roots of living mangroves (*Avicennia*), on steel plates and chains, on buoys of all kinds, and the shells of molluscs such as mussels. Its bathymetrical range seems to extend from the level of the low water mark of neap tides down to considerable depths (at least 50 feet on the deep timber test samples set by the Preservation and Research Laboratory of the Maritime Services Board in Bantry Bay, Middle Harbour). According to records at present available, both varieties of this barnacle appear to grow with equal facility at all depths and often they appear side by side in the one place.

Localities.—On the bottom of a yacht and on a buoy in Pittwater; on pilings, boat bottoms, living mangroves, and timber test samples in Middle Harbour; on steel test plates at Fort Macquarie picnic jetties, Port Jackson; on piling of baths in Rose Bay, Port Jackson; on the bottom of a boat at Carramar, George's River; also on pilings and timber test samples from numerous stations in the Parramatta and Lane Cove Rivers, which form the upper reaches of the Port.

Remarks.—*B. amphitrite*, and especially var. *cirratus*, is by far the most common of the barnacles fouling harbour installations and small craft in this Port. From information supplied by Mr. D. Moore the young of this barnacle are believed to make their first appearance on timber test samples in the months of November, December and January and to grow to adult size in a few months.

Mud seems to have little or no effect on this species, for they flourish in situations where they are so choked by it that their shells are completely obscured. Also certain chemical wastes which are poured into the Parramatta River at various points seem to have little effect on the barnacle populations. Some of them, no doubt, are of an oily nature and therefore float on top of the water and so come in contact only with those barnacles which live between tide marks.

B. amphitrite var. *cirratus* seems to have a tolerance of a wide range of salinities, for it is found anywhere from the main harbour waters, where the salinity is that of normal seawater, to places such as Carramar on the George's River, where the salinity is never more than eight parts per thousand.

On the wharf piles in the upper reaches of the Port, the zones inhabited by *Elminius modestus* and *B. amphitrite* overlap and unless a sharp watch is kept it is quite possible to confuse small specimens of *B. amphitrite* with large ones of *Elminius* since the shapes of the orifices are similar and even the valves have a superficial resemblance. A count of the number of plates will settle the matter at once.

B. amphitrite, and especially var. *communis*, is often found on the pneumatophores and trunks of mangrove trees, together with *Elminius modestus*, and there is a possibility that Hedley mistook this species for *B. trigonus*.[1] An examination of barnacle clusters on mangroves in the Middle Harbour area has failed to disclose a single specimen of *B. trigonus*, whereas the colouring of the specimens of *B. amphitrite* var. *communis* which were there, might have been confused with that of *B. trigonus* if only a cursory glance was given to them, for the purply-violet stripes on the plates are wide enough in some specimens to give the illusion of being the ground colour, and the white between looks like the ribs. However, the opercular valves settle the matter at once.

[1] See note under *B. trigonus* on this matter.

Balanus (Austrobalanus) imperator Darwin.

(Plate xxviii, figs. 8 and 10; Plate xxx, figs. 11–12.)

Appearance.—The shell is moderately large, conical, and thick-walled, and generally very much encrusted by coralline growths and worm tubes. Also where the shell is much eroded the appearance is whitish. The walls of the shell-plates are solid and have no pores in them. The radii are poorly developed and are whitish in colour and marked by some low, irregular, wavy, transverse septa. The lower portions of the edges of the plates bear white dendritic septa which interlock with corresponding depressions in the next plate. The sutures are almost obliterated externally, being very firmly joined together and masked by the corrugations on the outside of the shell. The basal edges of the shell plates have a characteristic nodular appearance (Plate xxviii, fig. 10). The orifice is generally irregular and eroded.

Size.—A typical specimen has basal diameter one and one-quarter inches with the height slightly less than one inch. In maximum sized specimens the basal diameter reaches one and three-quarter inches.

Basis.—The basis is extremely thin and calcareous (it might almost be mistaken for a membranous one unless a chemical test is made) and is composed of a mosaic of tiny granules. There are no pores among these granules.

Colour.—Externally the barnacle often appears white or pink owing to erosion or overgrowths, but internally the walls are seen to be a deep imperial purple in colour.

Opercular Valves.—Internally the opercular valves are yellowish-white in colour with dark purple patches developed near the apices. The scutum is triangular in shape with a very acute apex. The articular furrow is narrow and there are well-marked ridges for the attachment of muscles at both the rostral and basi-tergal corners of the valve. The tergum has a bluntly-pointed beak and a short, wide spur with a rounded end. There are many well-marked crests for the attachment of the tergal depressor muscles at the basi-tergal corner of the valve.

Habitat.—*B. imperator* lives attached to rocks and appears to require a certain degree of shelter, but, on the other hand, cannot tolerate still water, probably owing to the depositions of mud which would result from these conditions. It does not frequent the very exposed spots favoured by *B. nigrescens*, but inhabits the same tidal zone, choosing, however, more sheltered nooks and crannies among the rocks and boulders of the open coast. In harbour waters, where *B. nigrescens* finds the water movements insufficient for its needs, *B. imperator* seems to reach its best development, and at points near the outlet of the Port, where there is a reasonable swell, e.g. Bottle and Glass Rocks, Vaucluse, it becomes the dominant barnacle at the level of low water mark of spring tides.

Localities.—In sheltered crannies and rock pools at Newport; Long Reef and Harbord. On the tops of rocks at Bottle and Glass Rocks, Vaucluse, Port Jackson; Hunter's Beach, Balmoral, Port Jackson; and Steele's Point, Port Jackson.

Remarks.—Since *B. imperator* attaches itself only to stones and requires a certain amount of movement in the surrounding water, it is not a fouling organism in the Port. Darwin (1854) points out that the reduction in size of one of the pairs of lateral plates (the carino-lateral) till it is almost lost, makes this species more close than any other of the genus *Balanus* to the condition found in *Tetraclita* or *Elminius*, where there are four plates in the shell. The bases also bears a resemblance in these groups.

Balanus (Chirona) amaryllis Darwin.

(Plate xxviii, fig. 7; and Plate xxx, figs. 17–20.)

Appearance.—The shell is generally tubulo-conical in shape, moderately large, and has a comparatively large orifice. The latter is sub-rhomboidal in shape and generally deeply toothed. The carinal angle of the orifice is very acute and gives a spout-like appearance to this part of the shell. The outer sides of the parietes are smooth or slightly marked by horizontal ridges near the basis (like lines of growth). The radii are moderately developed, being narrow and having oblique summits. The alae have their

free edges almost parallel to the basis. The walls of the parietes are not permeated by pores, but are ribbed internally near the basis. The radii have no transverse septa on their edges, but the latter are slightly recurved.

Size.—Typical specimens are about one inch in height and have a basal diameter of from half to three-quarters of an inch. Large specimens of height three inches and basal diameter two inches have been recorded, but not from the Port Jackson area.

Basis.—The basis may be flat or cup-shaped, and is calcareous and permeated by radiating pores.

Colouring.—The colour is a pale rose-pink, with the alae white and very prominent, while the radii are little differentiated in colour from the parietes.

Opercular Valves.—Externally the scutum has prominent lines of growth which are divided by longitudinal grooves into small squarish sections which are plainly visible with the aid of a powerful hand lens. The tergum has a beaked apex which curves forwards over the scutum. There is also a long, narrow spur. Externally a deep longitudinal groove runs down the valve and the centre of the spur. The edges of this groove are folded inwards, and as the barnacle grows may in time come to obliterate the furrow completely .

Habitat.—*B. amaryllis* appears to be a deeper water form, since it is dredged in the harbour along with *B. trigonus* in depths of twelve fathoms or more. This species has not as yet been taken by the author in the tidal range even after much intensive searching, nor has it appeared on the timber test samples set by the Preservation and Research Laboratory of the Maritime Services Board at various points in the Port. It appears to settle on almost any type of substratum of a solid nature, such as shells, alcyonarians or pieces of rock.

Localities.—Off Ball's Head, Port Jackson, in twelve fathoms and below.

Remarks.—This species may reasonably be suspected of being a fouling organism on deep harbour structures or on boats with a very deep draught. It has not, as yet, manifested itself in this role in the Port, but the species has been recorded in other localities as appearing frequently on ships' bottoms.

Genus Tetraclita.

The genus *Tetraclita* comprises Balanid barnacles with four plates in the shell, the parietes of which are porose. Sometimes the sutures between the plates are obliterated externally, but they can be seen by examining the inside of the shell or by boiling it in a solution of caustic potash for some minutes. The basis is always flat, never cup-shaped. Two species of this genus are found in the Port Jackson district, *T. rosea* and *T. purpurascens*. Both are common species, but since they occur attached to littoral rocks and shells and rarely, if ever, attach themselves to anything other than rock, they are not of much importance as fouling organisms. Occasionally they may cause a nuisance in swimming pools made by hollowing out rocks (like some found on the open coast near Sydney) by scratching the bathers who cling to the side, but for the most part they can be neglected. The only place where the author has encountered this genus fouling harbour structures was where stone or concrete works or piles were near the open sea, at the harbour entrance.

The two local species of this genus are easy to separate by reason of the difference in structure of the pores of the parietes. In all but the very youngest specimens of *T. purpurascens* there is more than one row of parietal pores; usually there are ten to fifteen which, when viewed from below, have a honeycombed appearance.

In *T. rosea* there is only a single row of pores, formed by the large primary septa which extend from the outside lamina of the parietes across to the inside wall. In addition to these primary septa other strengthening septa grow inwards from the outside lamina, but do not extend across to the inner wall. Some of these secondary septa are branched as may be seen in Plate xxix, fig. 3. Their presence gives the characteristic appearance to the base of the shell of *T. rosea*.

Other species of this genus, not found in the vicinity of Port Jackson, have a honeycombed appearance on the base of the parietes also. *T. squamosa*, for instance, which occurs in more northerly waters and does not grow here, is very similar in the appearance of its base to *T. purpurascens*, but for local barnacles the following key is sufficient:

Key to the Species of Tetraclita.

A. Walls of the parietes enclosing a single row of rather peculiar pores; basis thin and calcareous ..... Sub-genus *Tesseropora*. *T. rosea*

AA. Walls of parietes with many rows of small pores, so that there is a honeycombed appearance. Basis membranous ..... *T. purpurascens*

Tetraclita (Tesseropora) rosea (Krauss).

(Plate xxix, figs. 2–3; and Plate xxx, figs. 21–22.)

Appearance.—The shell is steeply conical, and in young and uneroded specimens the sutures between the four plates are quite distinct. In older, eroded shells the sutures often become indistinct. The radii are narrow and have their free edges crenated, but they are only seen clearly in uneroded specimens. If uneroded, the outside lamina of the parietes is smooth; if, however, disintegration has set in, the upper parts of the shell have a columnar appearance owing to the fact that the large, square tubes of the parietes become partly filled with shell matter and the wearing away of the outside lamina exposes them. When the parietes are viewed from below there is seen to be a single row of rather rectangular tubes or pores. It is the possession of this single row of pores which assigns the species to the sub-genus *Tesseropora*. Adults of other species of the genus always have more than one row of pores.

The orifice is pentagonal in uneroded specimens, but as it wears, its shape changes through rhomboidal to triangular in the largest worn specimens.

Size.—Typical specimens are about three-quarters of an inch in basal diameter and half an inch in height. The largest specimen collected was slightly more than one and one-tenth of an inch in basal diameter and its height was slightly more than half an inch.

Basis.—The basis is mostly calcareous, consisting of a very thin, central, calcareous plate which, towards the edge of the shell, becomes merely membranous. The basis is almost invariably left on the rock when the barnacle is removed, and in order to test its calcareous nature an application of hydrochloric acid may be necessary. The bubbles of carbon dioxide given off by the basis will prove its calcareous nature.

Colour.—Young specimens are a dirty grey in colour with traces of pink towards the tips of the compartments. In eroded specimens the colour is pink.

Opercular Valves.—The opercular valves are generally much eroded externally. The scutum is a thick, solidly built valve with a deep articular furrow. There is a prominent adductor ridge and a deep scar for attachment of the adductor muscle. There are three to five small crests for attachment of the lateral depressor muscle. The tergum is also heavily built and rather small and has a short, broad, bluntly-pointed spur close to the basi-scutal angle of the shell. There is a wide articular furrow and crests for the attachment of the depressor muscle.

Habitat.—This species is very common on rocks and shells on the exposed parts of the coast and near the mouth of the Port, where it is found round about the level of the low neap tide mark. It lives above the level frequented by *B. nigrescens* and is often associated with *Catophragmus polymerus* on flat rock platforms.

Localities.—Newport; Long Reef; Harbord; Manly; Bondi; Maroubra; Cronulla; Bottle and Glass Rocks, Vaucluse, Port Jackson; Steele's Point, Port Jackson; Hunter's Beach, Balmoral, Port Jackson; Middle Head, Port Jackson; Bradley's Head, Port Jackson.

Remarks.—Since this barnacle is found on the rocks of the open coastline or near to the mouth of the Port, where the surge of the waves is considerable, it is not numbered among the fouling organisms of the Port, especially as it attaches itself only to rocks and shells above low water mark. It does not attach itself to wooden substrata.

The orifice appears to enlarge itself as the barnacle grows, by the wearing away of the tops of the shell-plates rather than by the growth of the radii and alae, so that the corrosion of the shell is an important factor in its growth.

Tetraclita purpurascens (Wood).

(Plate xxix, figs. 1 and 3; Plate xxx, figs. 23–24.)

Appearance.—The shell of this barnacle is generally in the form of a very much depressed cone, with a more or less diamond-shaped orifice unless the specimen is worn, when the orifice is sub-rhomboidal. Two distinct forms are found, so different in external appearance that they might be mistaken for two species if intermediate types did not show the transition from one to the other. In uneroded specimens the four plates of the shell are easily seen, the radii are wide and well developed, having their tops parallel to their bases. On the parietes of the shell-plates are developed from five to six clear, longitudinal ribs (Plate xxix, fig. 1).

In the eroded form, where the outer lamina is completely gone, the shell has a rough, granular appearance and there is little or no trace of the sutures between the plates. The radii are little developed and the orifice is enlarged only by the wearing away of the summits of the plates, so that the shape of the orifice is more rhomboidal and not diamond-shaped. There may be no trace of ribs on the parietes. Plate xxix, fig. 1, shows an eroded specimen of *T. purpurascens*.

In both types of this species the bottom of the shell-plates shows the same structure, namely numerous rows of pores running up into the parietes so that there is a honeycombed appearance to the bottom of the shell (Plate xxix, fig. 3.).

Size.—The basis of a typical specimen is from three-quarters to one inch across, but the shell is only about a third of an inch high. Comparatively this is much lower than *T. rosea*, with which it is occasionally found on rocky shores. Very large specimens may be slightly more than one inch across in basal diameter.

Basis.—The basis of the shell is entirely membranous, thus differing from other described Tetraclitas.

Colour.—The colour ranges from ivory-white in specimens which have grown in shaded spots with a good degree of shelter, to dirty-grey in eroded forms, or sometimes a pale mauve tinge colours the shell.

Opercular Valves.—The scutum is much more elongated in *T. purpurascens* than in *T. rosea*, and has a wide, shallow articular furrow. The adductor ridge is not as prominent in this species as in *T. rosea*, being merely a shallow ridge, lying nearly parallel to the basal margin. Sometimes none is present. There are no crests for the attachment of the depressor muscles, this purpose being served by some small pits. The tergum is a small valve about half the size of the scutum and has little or no spur, for what there is merges with the basi-scutal corner, thus differing again from *T. rosea*. There is a wide, shallow articular furrow, and there are five or six crests for attachment of the depressor muscles.

Habitat.—*T. purpurascens* appears to attach itself either to stones or to wooden wharf piles and to grow equally well on the open coast as near the mouths of estuaries. It inhabits a high level on the rocks, extending from a little above low water mark to a point a little above high water mark of neap tides. It is, therefore, associated with *T. rosea* at the bottom of its range and with *Chthamalus antennatus* at the top. It differs in its habits from the two latter species, however, in that it prefers a shaded situation such as the sides or the lower surfaces of boulders. In fact, it seems to flourish best on the under sides of large, sloping boulders below which water can swirl at high tide. It is in such situations that the ivory-white forms are found. *T. rosea* seems to prefer the upper sides of boulders.

Localities.—Pittwater on boatshed piles; Newport; Long Reef; Harbord; Hunter's Beach, Balmoral, Port Jackson; The Spit, Middle Harbour; Bottle and Glass Rocks, Vaucluse, Port Jackson; Rose Bay, Port Jackson; Middle Head, Port Jackson, and at Bradley's Head, Port Jackson.

Remarks.—Although *T. purpurascens* may attach itself to stones, wood or molluscs, it is not a fouling organism of any note in the Port. This is due to the fact that it requires to live in the tidal range and in spots where there is a good deal of water movement. It does not penetrate, therefore, to the upper reaches of the Port.

Tetraclita radiata (Blainville).

In a previous paper[1] the author recorded *T. radiata* as occurring at Long Reef, near Collaroy, but this was due to a mistaken identification. The species taken there was, in fact, *Elminius simplex*, and *T. radiata* has not as yet been found in the neighbourhood of Port Jackson.

Genus Elminius.

The genus *Elminius* comprises Balanidae with only four plates in the shell, and these have solid walls not permeated by pores. The basis is always membranous.

Two species of the genus occur in the Port Jackson area, *Elminius simplex* and *E. modestus*. The latter is a prominent fouling organism in the upper reaches of the Port, since it grows on wood, stone or any other substratum with equal facility. *E. simplex* is moderately rare and is not of importance as a fouling organism.

There should be little difficulty in separating these two species because of the difference in size between them and also the difference in their field occurrence. *E. modestus* rarely, if ever, exceeds one-quarter of an inch in basal diameter and is found growing on any sort of substratum at the level of the high neap tides and above. It occurs in harbours and estuaries where there is a slight admixture of mud in the water and on the bottom. *E. modestus* occupies the level on the rocks which is colonized in more seaward parts of the harbour and on the open coast by *Chthamalus antennatus*. In fact it is possible to find these two barnacles occurring side by side in certain parts of the harbour.

E. modestus is as a general rule rather dull muddy-grey in colour and has a comparatively large orifice. It may grow crowded together, when it has a more tubular shape, or it may be solitary, when it is flattened conical. This latter is usually only at the extreme upper limit of its range.

E. simplex, on the other hand, is found on the under side of boulders and ledges of rock, near the low water mark of spring tides. It has not, in the author's experience, so far been collected in muddy situations and has a rather solitary habit of growth. Two or three may be found under the one boulder, but they are never crowded together. The colour is white and the outside of the parietes of the shell is longitudinally ribbed and has a regular corrugated appearance. When one of the shell-plates is broken across, parallel to the basis, and the fractured edge is examined under the microscope, a row of minute dark yellow dots can be detected between the outer and inner laminae of the parietes. *E. simplex* is larger than *E. modestus*, the usual adult size being about half an inch basal diameter. The shape is also more steeply conical in *E. simplex* than in *E. modestus*.

Key to Species of Genus Elminius.

A. Up to a quarter of an inch basal diameter; colour of shell greyish-brown or grey; grows in muddy estuaries near high water mark of neap tide; has comparatively large orifice ..... *E. modestus*

AA. Generally about half an inch basal diameter; colour of shell white; shell steeply conical with comparatively small orifice; parietes longitudinally ribbed or corrugated; frequents open coast and attaches to under side of rocks near low water mark. A characteristic row of microscopic yellow dots lies between the inner and outer laminae of the parietes ..... *E. simplex*

Elminius modestus Darwin.

(Plate xxix, fig. 4; and Plate xxx, figs. 27–28.)

Appearance.—This very common, small barnacle has, as a rule, a flattened conical shape, though where specimens grow in very crowded conditions there is some tendency

[1] "Animal and Plant Communities of the Coastal Rock Platform at Long Reef, New South Wales", *Proc. Linn. Soc. N.S.W.*, Vol. lxviii, Parts 5 and 6, 1943.

for the shell to become tubular. The outside walls of the four shell-plates are smooth and faintly ribbed longitudinally, this ribbed structure being most marked in the large, rather solitary specimens which grow on the mangroves (*Avicennia*) in the upper reaches of the Port and Middle Harbour. The shell is comparatively fragile in that the plates come apart easily when the barnacle is removed from its substratum. The orifice is large and diamond or rhomboidal in shape and is not toothed. The scuta generally have a light coloured, longitudinal band running outwards from the apex to the margin of the valve. The walls of the parietes are not permeated by pores.

Size.—Typical specimens are slightly less than a quarter of an inch in basal diameter, while large ones reach half an inch. Such large specimens, however, are very low and flattened and the continuations of the ribs stick out round the margin of the shell in a series of points.

Basis.—The basis is membranous and flat.

Colour.—The colour is rather variable, being pale grey in specimens on rocks exposed to full sunlight, while ones from more shaded habitats such as wharf piles and walings or mangroves are very dark grey-brown with light ribs of white or pale grey. The light band running across the scutum often seems to be confluent with one of the light coloured ribs on the lateral plates of the shell. The rest of the opercular valves are generally darker than the remainder of the shell.

Opercular Valves.—The scutum has no remarkable characters, for the adductor ridge is no more than an undulation. The articular ridge is moderately well developed and has a slight peak in the centre. The articular furrow is shallow and comparatively wide towards its basal end. There is a small depression for the attachment of the lateral depressor muscle. The tergum is a small valve, rather variable in shape. In local specimens the most usual condition is for the valve to be hatchet-shaped because the basal margin is very deeply notched, thus dividing the valve into two portions. There is no spur, for it is incorporated into the basi-scutal corner of the valve (the handle of the "hatchet") and this section of the valve is long and narrow, and grooved down the centre. The articular ridge is prominent and forms one of the sides of the groove. The other section of the valve, the basi-carinal corner, has several crests on it for the attachment of the depressor muscles. Occasionally the notching of the basal margin is not so marked and the basi-carinal portion of the valve is, in consequence, broader and larger.

Habitat.—*E. modestus* is an estuarine barnacle and is easily the most common barnacle growing in the inter-tidal area of the harbour, for it grows on any kind of substratum. It frequents the highest parts of the inter-tidal area (from about high neap tide mark up to high spring tide mark) and seems to have a wide tolerance of mud in the surrounding waters or it could not frequent the mangrove swamps. On the other hand, *E. modestus* is not found very near the entrance to the Port where there is much wave action.

Localities.—In Port Jackson it occurs at the following localities: Hermit Bay, Fort Macquarie picnic jetties, Long Nose Point, Cabarita, Mortlake, and Homebush Bay, Woodford Bay on the Lane Cove, and at Seaforth, Sugarloaf Bay and Roseville Bridge in Middle Harbour.

Remarks.—Although its powers of growing with equal facility on all types of substratum would appear to make this species a menace as a fouling organism, its habit of growing only towards the upper limit of the tidal range prevents it from becoming much of a nuisance on ships and small craft. However, the parts of wharf piles and walings which come within its range of settlement are practically always completely encrusted by *E. modestus*. The rocks of the harbour foreshores in the upper reaches are frequently also encrusted to the same extent, so that *E. modestus* fulfils inside the estuary the role that *Chamaesipho columna* takes outside, except that *E. modestus* inhabits a higher level than its counterpart.

E. modestus is mostly associated with *Balanus amphitrite* var. *communis* on wooden substrata, since the two species are found side by side on wharf piles and walings and

on the stems and roots of mangroves. Hedley (1915) makes no mention of *E. modestus* in his very able paper on the "Ecology of the Sydney Beaches", and this fact is hard to reconcile with the vast numbers which are found in the Port. Darwin (1854) is of the opinion that both species of the genus *Elminius* do not extend their range much to the north of Port Jackson and they are, therefore, southern forms.

Elminius simplex Darwin.

(Plate xxix, fig. 5; and Plate xxx, figs. 25–26.)

Appearance.—The shell is comparatively tall and steeply conical, corrugated externally by foldings of the parietes. The rostral plate is often backwardly curved. The orifice is generally small and pentagonal and has a somewhat jagged edge. The sutures between the shell-plates are always well marked and the radii are very narrow. The shell is generally little eroded and the sculpture, in consequence, well shown. The walls of the parietes are solid and when broken across, and viewed under a microscope, show a row of tiny orange dots between the outer and inner laminae.

Size.—Typical specimens are about half an inch in basal diameter and about the same height. The largest specimen collected by the author is only a little larger than these dimensions, being five-sixths of an inch in basal diameter and three-quarters of an inch high.

Basis.—The basis is flat and membranous.

Colour.—The colour is white or off-white and the insides of the opercular valves show faint purple tinges. The orange dots show only when the parietes are broken across.

Opercular Valves.—The scutum is a comparatively thick, solidly built valve. There is a prominent adductor ridge and a long, rather pronounced articular ridge. At the basi-tergal corner of the valve are six or seven small crests for the attachment of muscles. The occludent margin is distinctly infolded towards the basal part of the valve. The tergum is very much elongated along the basal and scutal margins by the incorporation of the rounded spur into their length—the edges of the spur being confluent with both these margins. There is a prominent, wide articular furrow, a beaked apex and approximately six radiating crests for the attachment of muscles towards the basi-carinal corner of the valve. The articular ridge is prominent and merges with the raised central area of the spur. The valve in local specimens does not appear to be so similar in shape to that of *E. simplex* (a New Zealand species) as Darwin states in his description, although the scuta are similar.

Habitat.—This species has been collected by the author only from the under sides of boulders or in holes under overhanging ledges of rock platforms on the open coast. It is probably the rarest sessile barnacle in the Port Jackson area and has not, so far, been found inside the Port itself. This would indicate that the species requires a considerable amount of movement in the surrounding water as well as showing a preference for subdued lighting or no light. It lives at low water mark of spring tides.

Localities.—Under boulders at Long Reef; Newport and Harbord.

Remarks.—This species seems to settle only on stony substrata and to frequent the open coast, so that it does not figure among the fouling organisms of the Port.

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Summary.

The barnacles found in Port Jackson and the surrounding districts are described and a simplified key for their identification is supplied, together with a few notes of their field occurrence.

The species dealt with are as follows:

Catophragmus (*Catomerus*) *polymerus* Darwin.
Chthamalus antennatus Darwin.
Chamaesipho columna (Spengler).
Balanus (*Megabalanus*) *nigrescens* Lamarck.
„ (*Balanus*) *trigonus* Darwin.
„ (*Balanus*) *amphitrite* Darwin var. *communis* Darw.
„ „ „ „ „ *cirratus* Darw.
„ (*Austrobalanus*) *imperator* Darwin.
„ (*Chirona*) *amaryllis* Darwin.
Tetraclita (*Tesseropora*) *rosea* (Krauss).
„ *purpurascens* (Wood).
Elminius modestus Darwin.
„ *simplex* Darwin.

A correction of an error made in a previous paper with regard to the occurrence here of *Tetraclita radiata* is made.

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EXPLANATION OF PLATES.

PLATE XXVIII.

Fig. 1.—*Catophragmus* (*Catomerus*) *polymerus* Darwin. Three whole shells. × 1.

Fig. 2.—*Chamaesipho columna* (Spengler). Bottom left: A piece of rock with conical, less crowded barnacles. Bottom right: Crowded specimens in a honeycomb-like mass. Top: The lower edges of the shell showing characteristic crinkly appearance. × 1½.

Fig. 3.—Inter-tidal rock showing mass and numbers of *Chamaesipho columna* (Spengler). Photograph by Miss G. Burns. × ½.

Fig. 4.—*Chthamalus antennatus* Darwin. Four little eroded specimens. × 2.

Fig. 5.—*Balanus* (*Balanus*) *amphitrite* var. *communis* Darwin. Whole shells. × 1½.

Fig. 6.—*Balanus* (*Balanus*) *amphitrite* var. *cirratus* Darwin. Top shell shows conical form. Lower shell shows tubular form. × ½.

Fig. 7.—*Balanus* (*Chirona*) *amaryllis* Darwin. Whole shells. × ½.

Fig. 8.—*Balanus* (*Austrobalanus*) *imperator* Darwin. Top left: A small uneroded shell. Top right: A much eroded specimen. Lower group: A clump of shells overgrown with brown alga and worm tubes. × 1.

Fig. 9.—*Balanus* (*Megabalanus*) *nigrescens* Lamarck. Top: Two old and encrusted shells. Bottom: Two younger specimens from the same locality. × ½.

Fig. 10.—*Balanus* (*Austrobalanus*) *imperator* Darwin. Lower edges of the plates of the shell. × 1.

Plate XXIX.

Fig. 1.—*Tetraclita purpurascens* (Wood). Whole shells. Two specimens on the left uneroded. Two specimens on the right eroded and showing granular appearance. × 1½.

Fig. 2.—*Tetraclita* (*Tesseropora*) *rosea* (Krauss). Whole shells. Those on the left are much eroded. Those on the right comparatively uneroded. × 1½.

Fig. 3.—Structure of shell walls in genus *Tetraclita*. Left: *T. rosea* (Krauss) with single row of pores. Right: *T. purpurascens* (Wood) with numerous rows of pores. × 1.

Fig. 4.—*Elminius modestus* Darwin. Some whole shells growing on bark and two specimens from a rocky substratum. × 2.

Fig. 5.—*Elminius simplex* Darwin. Two whole shells. × 1½.

Fig. 6.—*Balanus* (*Balanus*) *trigonus* Darwin. Two whole shells of *B. trigonus* on a mussel shell together with seven specimens of *B. amphitrite* var. *cirratus* Darwin. Note the prominent white ribs on *B. trigonus* Darwin and the rows of little pits on the scutum of the specimen in the lower right hand corner of the photograph. × 1.

Plate XXX.

Figs. 1-2.—*Catophragmus* (*Catomerus*) *polymerus* Darwin. Inside view of scutal and tergal valves.

Figs. 3-4.—*Chthamalus antennatus* Darwin. Inside view of scutal and tergal valves.

Figs. 5-6.—*Chamaesipho columna* (Spengler). Inside view of tergal and scutal valves.

Figs. 7-8.—*Balanus* (*Megabalanus*) *nigrescens* Lamarck. Inside view of scutal and tergal valves.

Figs. 9-10.—*Balanus* (*Balanus*) *trigonus* Darwin. Outside of scutal valve and inside of tergal valve.

Figs. 11-12.—*Balanus* (*Austrobalanus*) *imperator* Darwin. Inside view of tergal and scutal valves.

Figs. 13-14.—*Balanus* (*Balanus*) *amphitrite* var. *cirratus* Darwin. Inside view of scutal and tergal valves.

Figs. 15-16.—*Balanus* (*Balanus*) *amphitrite* var. *communis* Darwin. Inside view of tergal and scutal valves.

Figs. 17-20.—*Balanus* (*Chirona*) *amaryllis* Darwin. (17) Edge of radius which is smooth and slightly recurved. (18) Inside of tergal valve. (19) Outside of scutal valve. (20) Inside of scutal valve.

Figs. 21-22.—*Tetraclita* (*Tesseropora*) *rosea* (Krauss). Inside view of scutal and tergal valves.

Figs. 23-24.—*Tetraclita purpurascens* (Wood). Inside view of scutal and tergal valves.

Figs. 25-26.—*Elminius simplex* Darwin. Inside view of scutal and tergal valves.

Figs. 27-28.—*Elminius modestus* Darwin. Inside view of tergal and scutal valves.

All figures on this plate slightly larger than natural size.

G. C. Clutton, photo.

DIAGNOSES OF NEW MAMMALS FROM THE SOUTH-WEST PACIFIC.

By Ellis Troughton.

During the past year various "animal reservoir" collections of rats and marsupials have been submitted for determination at the Australian Museum by several United States research units, especially the U.S.A. Typhus Commission, as represented in the South-West operational areas by Lieutenant-Colonel Cornelius B. Philip and Major Glen M. Kohls.

The complexity of the mammalian fauna of New Guinea and the adjacent islands has been strikingly emphasized by examination of these important collections, and more or less tentative identifications have had to be supplied for the better known groups.

It has also become essential to provide new names for some outstanding forms in accordance with their physical and zoo-geographical relationships. It is hoped to provide a representative set of the "animal reservoir" collection for the U.S. National Museum at Washington. With this object in view, an effort will be made to amplify existing material during the period of service of the author with the Tropical Scientific Section of the A.I.F., under the direction of the Commonwealth Scientific Liaison Bureau.

The following preliminary diagnoses will be amplified in the course of a general revision of the animal reservoir collections associated generally with the scrub typhus collections.

Echymipera philipi sp. nov.

Diagnosis.—A diminutive species of the genus, distinguished from its nearest ally, *cockerelli* of the New Guinea mainland, by its smaller proportions and darker coloured and more spinous pelage.

Ear small and broadly triangular, a small indentation behind the tip; tragus triangular, simple, unfoliated. Tail definitely shorter than the head and faintly or smoothly ringed, with 19–20 scale-rings to the centimetre. Mammae 6.

Dimensions of young holotype male: External, female allotype in parentheses—head and body 170 (203); tail 52 (72); pes 35·5 (40); ear 23·5 × 16·5 (21·5 × 15·5) mm.

Skull: Greatest length 46·6; zygomatic width 21·2; palatal length 27·2; post-palatal foramina (one) 6 × 3·1; interorbital width 12·2; nasals 16·5 × 4·6; molars 1–3, 10·1 mm.

Holotype male M.6999, allotype female M.7028, and paratypes, male and female, in the Australian Museum, collected by Lt.-Col. C. B. Philip and Major G. M. Kohls on Owi Island, in the Schouten Group, New Guinea.

Petaurus kohlsi sp. nov.

Diagnosis.—A small but long-tailed insular species, warranting specific distinction because of the dark fuscous brown body-coloration, which almost eliminates the characteristic dorsal stripe; the somewhat paler ventrum is relieved only by a strongly defined creamy-white irregular patch in the middle of the somewhat paler centre of the belly. There is no trace of the yellowish edging to the side membranes, or the pale grey or yellowish tipping characteristic of races of *papuanus*, while the tail is proportionately much longer.

Coloration of back, head, and forelimbs about dark mummy-brown (Ridgway); hind part of legs and basal three-fourths of tail decidedly paler, about deep olive-buff flecked with buffy-brown, contrasting with the dark brown of the body and outer fourth

of the tail. Undersurface about dark buffy-brown, with blackish mummy-brown edging to the membranes; a sharply contrasted irregular whitish patch on the mid-ventrum.

Dimensions.—Adult female holotype with head and body 128 and tail 180, contrasted with 135 and 155 respectively in the young adult male holotype of *P. papuanus tafa.* described from Mt. Tafa, Central Division of Papua; pes 24; ear 22 × 13·5, reaching to middle of eye.

Skull: Greatest length 33·6; zygomatic width 23·3; palatal length 17·5; nasals 12·2 × 3; interorbital, greatest width across strong processes 9·5, least width 7·4; teeth, p^4–m^4 7·4, m^{1-3} 5 mm.

Holotype male M.6998 in the Australian Museum, collected by Lt.-Col. C. B. Philip and Major G. M. Kohls on Owi Island of the Schouten Group.

Rattus owiensis sp. nov.

Diagnosis.—A small species, allied with the *ringens* group by the mammary formula 1–2=6, and in general appearance, but with a sparser and less spinous pelage, relatively longer and less rugose tail. Skull specially distinguished by a disproportionately heavy rostrum, and lack of well-defined supraorbital ridging, characters specifically distinguishing it from both the typical *ringens* and *mordax.* Coloration a softer buffy-brown streaked with blackish-brown, and lacking the coarse speckling or strongly spinous hairs of the New Guinea species. Tail relatively longer and darker, and scale-rings (9 to cm.) decidedly less rugose than in true *ringens.*

Dimensions of adult female holotype, and young adult allotype in parentheses: Head and body 170 (156); tail 166 (174); pes 36–38 (37–38·5), the measurement differing on each foot; ear 20·5 × 13·5 (20·3 × 15) mm.

Skull: Holotype female, greatest length 45; zygomatic width 21·5; palatal length 24·4; interorbital width 6·8; palatal foramina 8·4 × 3·6; nasals 18·2 × 6; rostrum, greatest width 7, depth 8·1; upper molar row 7·8, width of m^1 2·2 mm.

Holotype male M.6993, and allotype female M.6992, in the Australian Museum, collected by Lt.-Col. C. B. Philip and Major G. M. Kohls in August, 1944, on Owi Island in the Schouten Group.

Rattus browni gawae subsp. nov.

Diagnosis.—This small and richly fuscous race is definitely separated from the type series in the Australian Museum, and other geographical races, by the bright ochraceous coloration of the throat and chest, unusually dark pigmentation of the manus and pes, relatively very long tail, and proportionately lighter rostrum as indicated by the dimensions of the nasalia and palatal foramina.

Head tawny to cinnamon-brown, a darker Prout's brown (Ridgway) between the eyes and ears. General dark fuscous-brown of the back a mixture of ochraceous-tawny and mummy-brown tips; sides a clearer ochraceous-buff to tawny. Throat and chest a rich ochraceous-tawny, toning to a paler cinnamon-buff on the inguinal area. The dark brown of the mid-dorsum contrasts markedly with the clearer buffy sides, which are even more strongly contrasted with the tawny-red of the ventrum. Tail-scales 13 to centimetre. Mammae 2–2=8.

Dimensions of the holotype female: Head and body 109; tail 116; pes 25·5; ear 15·5 × 12·5 mm.

Skull: Greatest length 30·3; zygomatic breadth 14·5; palatal length 15·8; palatal foramina 5·3 × 1·9; interorbital width 4·8; nasals 10·5 × 3; upper molar row 5·3 mm.

The holotype female M.6370 in the Australian Museum, presented by Lieut.-Commander W. H. Harrington, then of H.M.A.S. *Swan*, who collected it "on the Gawa Island atoll" of the Marshall Bennett Islands on 27.7.1937. The isolation of this race on a small island between the Trobriands and Woodlark Island emphasizes its distinctness, while the dark pigmentation of the manus and pes and warmth of the colouring are suggestive of an unusual habitat, such as in some mangrove-haunting forms of *Melomys.*

Rattus rennelli sp. nov.

Diagnosis.—A medium-sized rat, more robust than *browni*, and averaging larger than *exulans*. Distinguished from both species by the decidedly larger skull, larger and much broader nasalia, and wider expansion of the palatal foramina.

General colour of the back ochraceous-tawny to Prout's brown. Underfur of the ventrum greyish, washed with a tipping of light buff. Ear reaching to posterior canthus of eye. Tail-scales 10–11 to centimetre. Mammae 2–2=8.

Holotype male M.4213 in the Australian Museum, presented by Mr. G. A. V. Stanley, who collected on Rennell Island, situated about 90 miles south-westward of San Christoval Island, Eastern Solomons.

Dimensions of the holotype male, and allotype female in parentheses: Head and body 149 (142); tail 156 (157); pes 30·5 (29·5); ear 18 × 14 (17·5 × 13·8) cm.

Skull: Greatest length 35·8; zygomatic width 17·2; palatal length 19·1; palatal foramina 6·9 × 2·8; interorbital width 5·5; nasals 13·6 × 4·5; upper molar row 5·5 cm.

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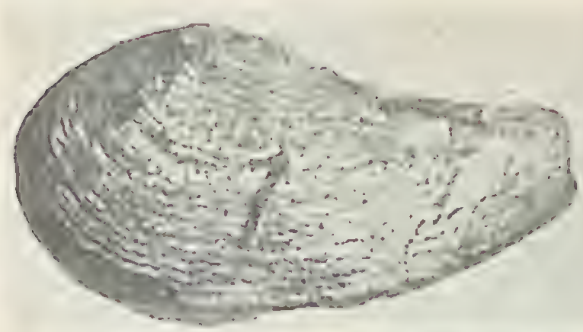

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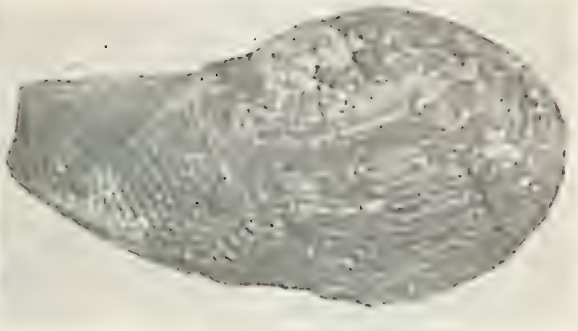

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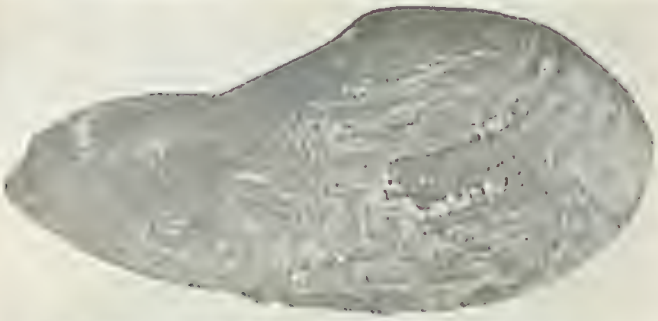

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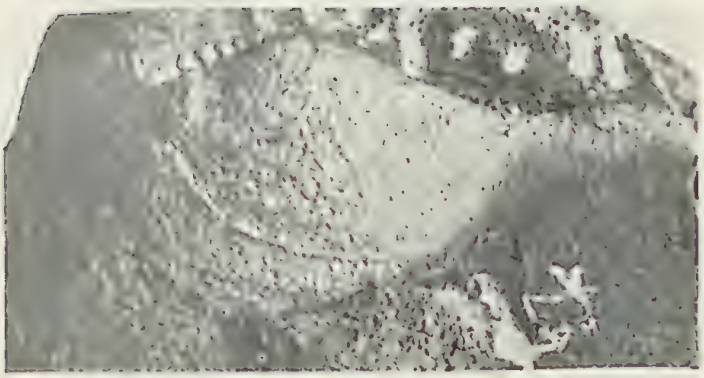

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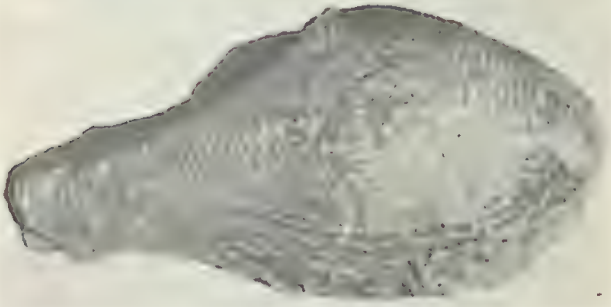

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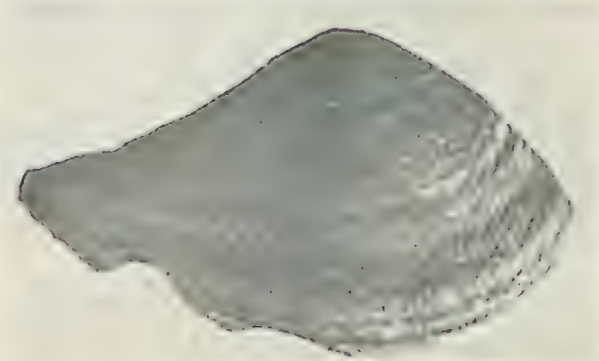

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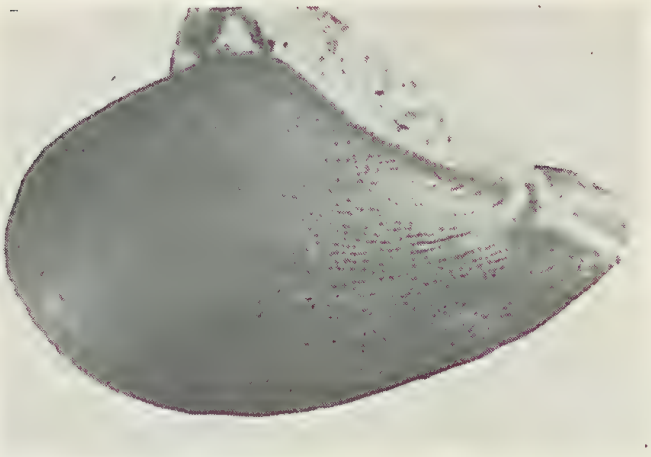

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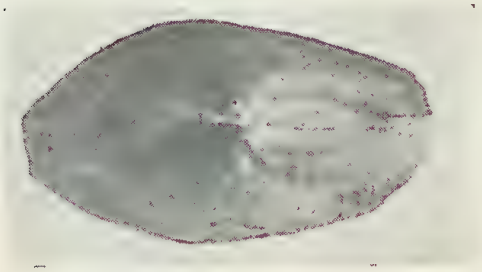

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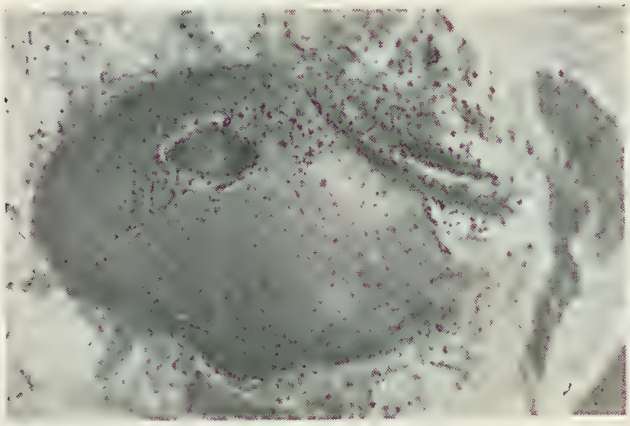

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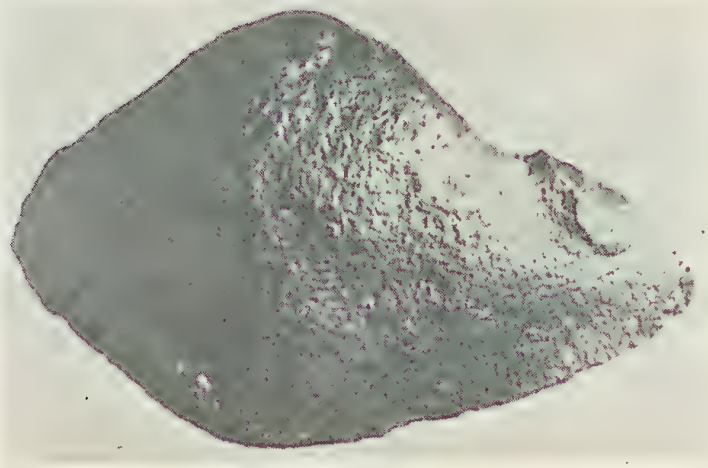

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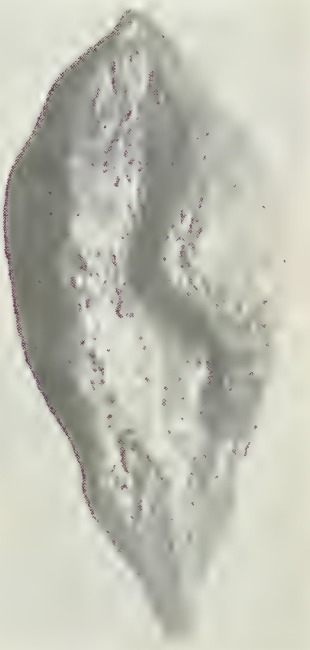

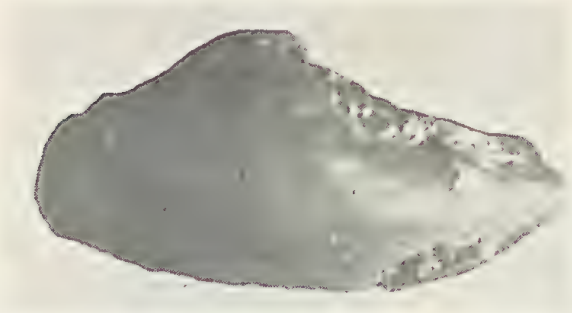

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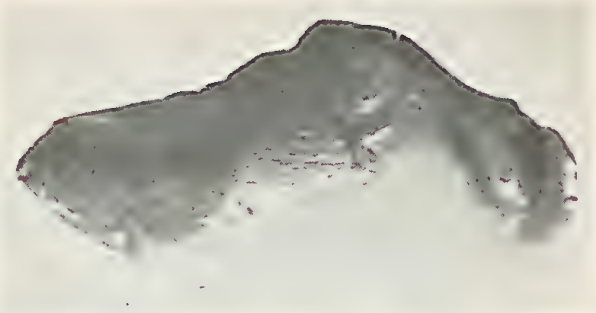

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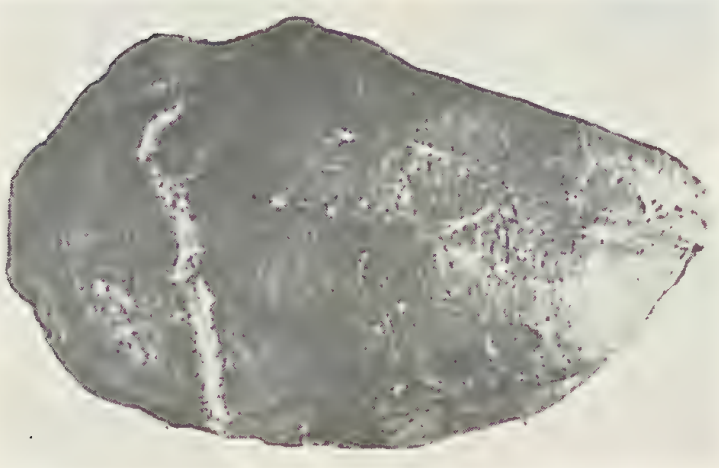

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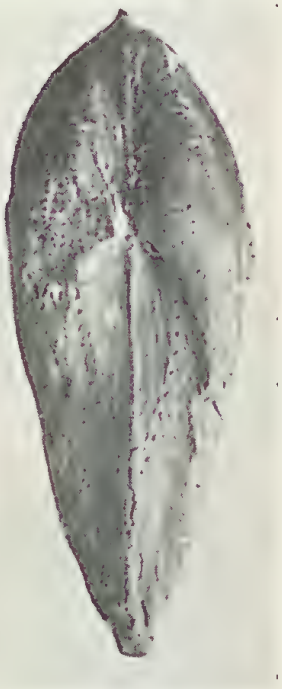

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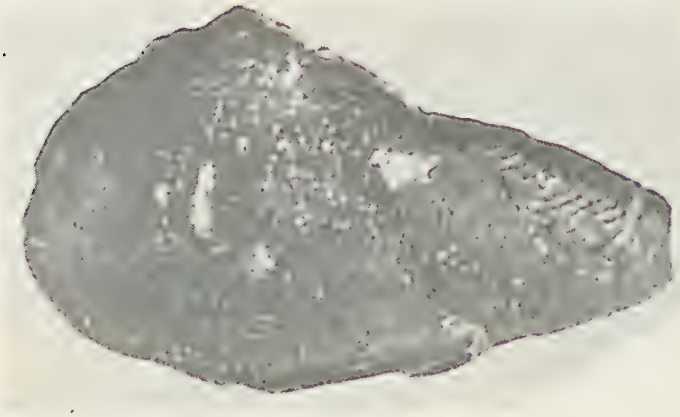

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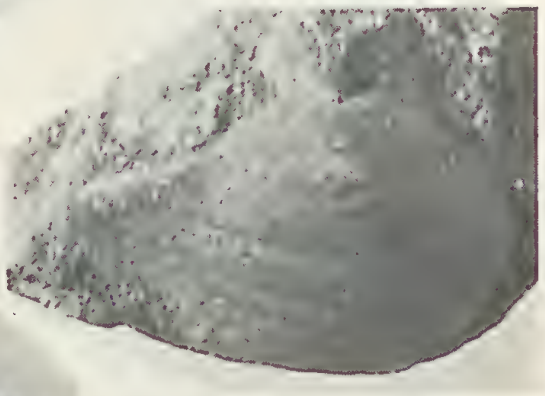

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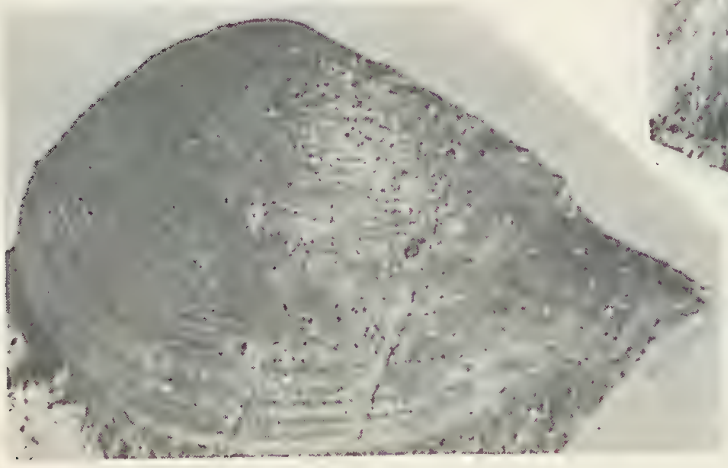

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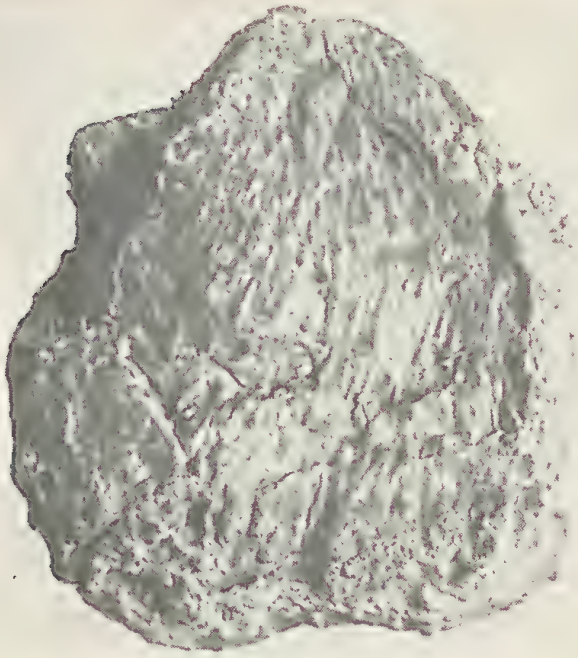

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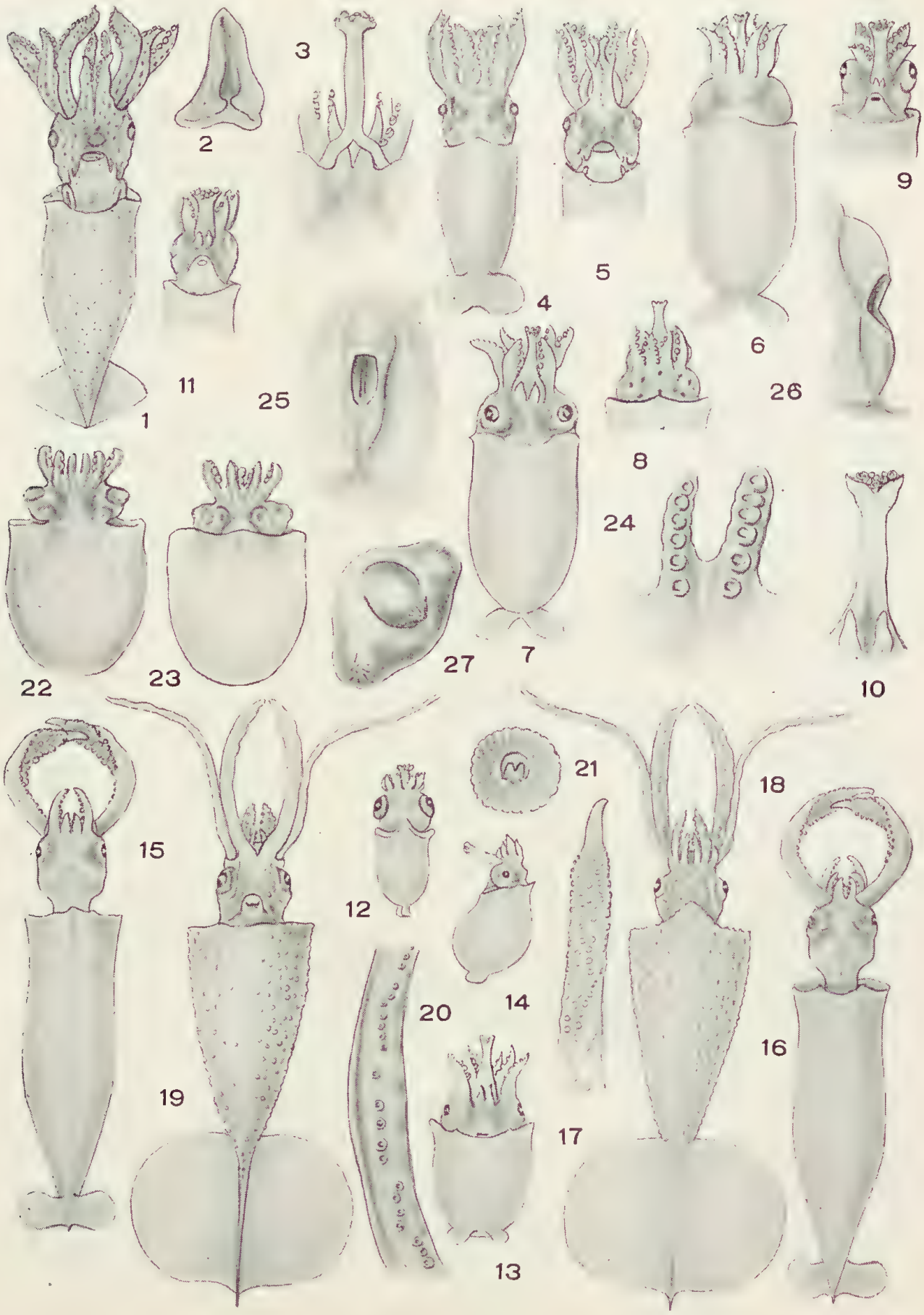
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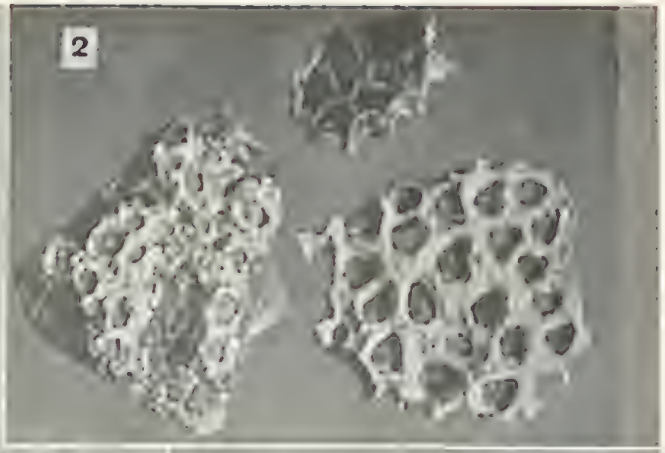
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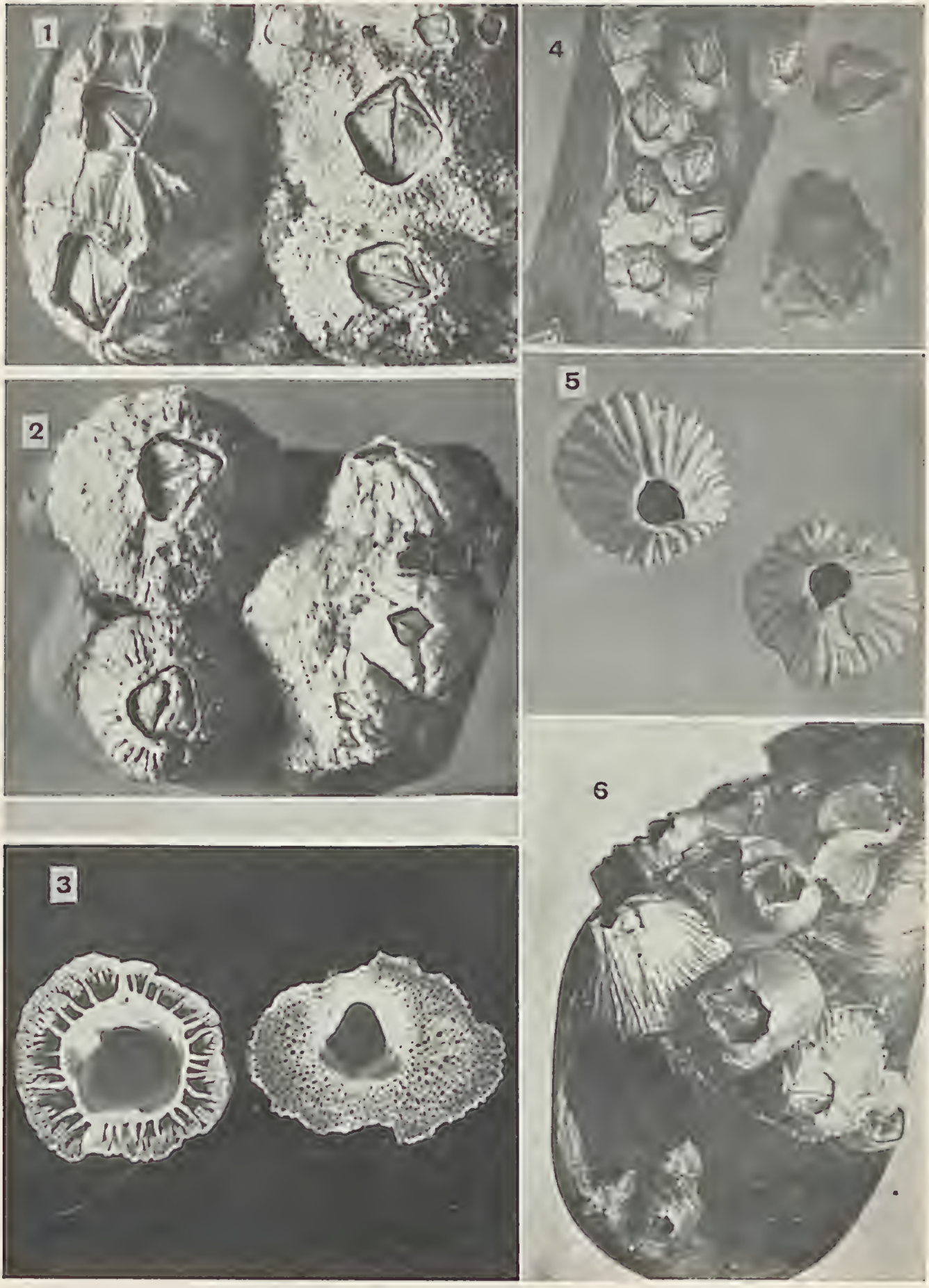
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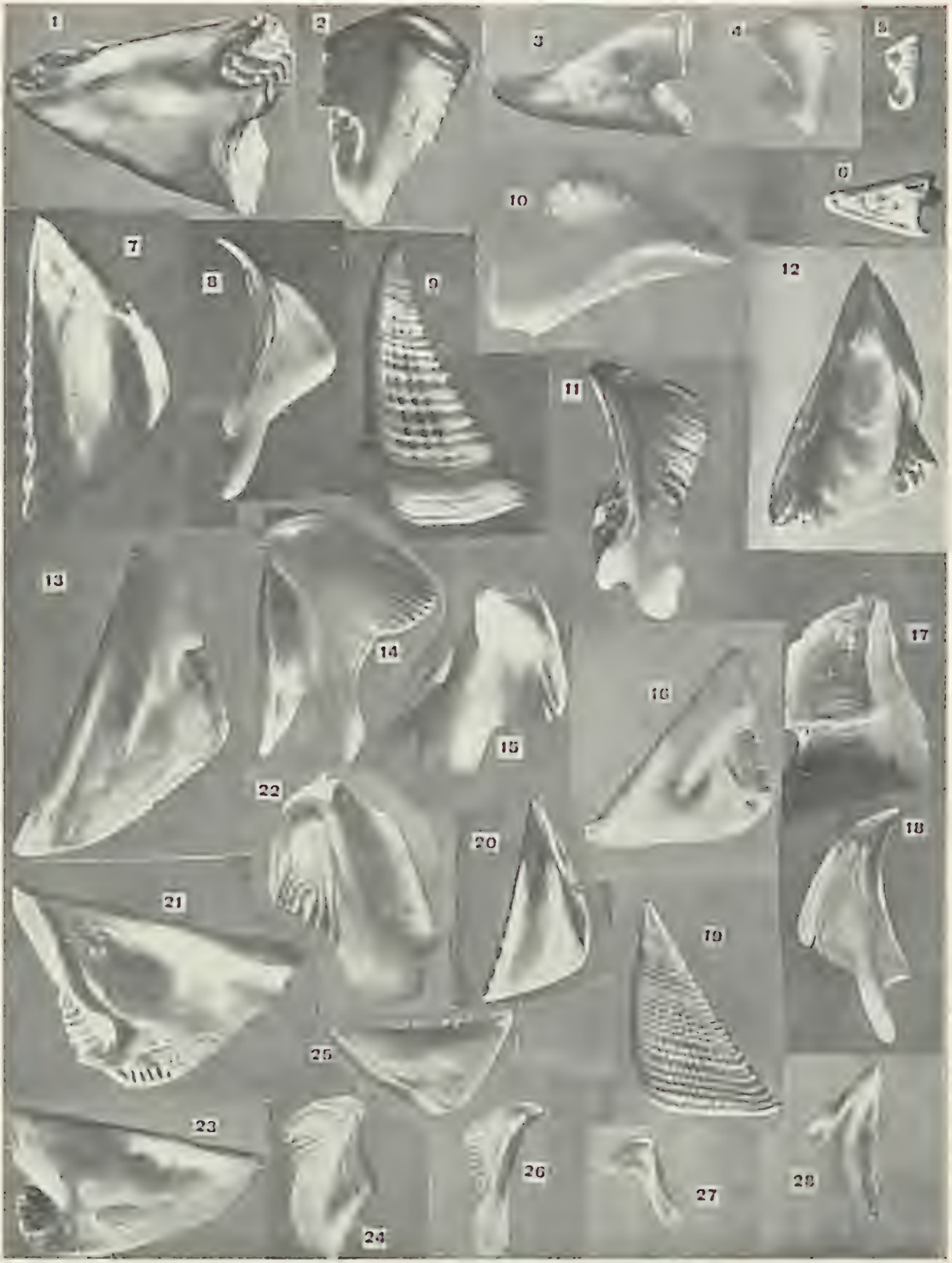

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T. Hodgchiths.

THOMAS HODGE-SMITH.

1894–1945.

Thomas Hodge-Smith was born at Swindon, Wiltshire, England, on 27th October, 1894, and was brought to Australia at the early age of two with his family. His father, the Reverend Michael Smith, a Presbyterian minister, was stationed at various places in New South Wales and eventually came to Double Bay, Sydney, where a good part of his boyhood was spent.

He was educated at Scots' College, the Sydney Technical High School, the Sydney Technical College and the University of Sydney. Before leaving school his thoughts turned to engineering, and once he actually left school to work for a time with a firm of engineers. He returned to complete his school studies and passed a competitive examination for entrance to a profession in the State Public Service. After some time he was offered a cadetship in the Geological Survey of New South Wales, and in 1913 became assistant to the late G. W. Card, Curator of the Mining Museum, for whom he always entertained an affectionate regard. It is interesting to note the influence of his sister, Mrs. C. D. Cotton, in his selection of mineralogy as his life's work. She was a research crystallographer before her marriage and they were very close companions not only then but in later life also.

The 1914-1918 war intervened largely in his life. For a time prior to 1914 he had been in the Naval Reserve; consequently the very night war was declared found him on his way to New Guinea with the Royal Australian Navy. Here, after having seen active service, he nearly died of blackwater fever and was invalided back to Sydney. After recovery and a period of further naval training, when he rose to the rank of sub-lieutenant, he finally forsook the Navy, although at one stage he apparently did contemplate making a career of it. He then joined the A.I.F., and in 1916 went overseas to France on active service as a sapper. His career as a soldier was cut short in 1918 by a shell which in bursting broke his leg and killed everyone else in his immediate vicinity.

He resumed service with the Mining Museum, but in 1919 he left there to join the staff of the Australian Museum and in 1921 became Mineralogist, succeeding the late Dr. C. Anderson, who had been elevated to the position of Director.

In the scientific world Hodge-Smith will be remembered as a morphological crystallographer and as an authority on Australian meteorites. He was specially interested in tektites, firmly believing in their celestial origin and in the theory of continuing fall. In his early years as mineralogist at the Museum, he carried out a good deal of field work, especially in connection with the occurrence of zeolite minerals in New South Wales and notably on the mica fields of Central Australia. He was a competent analyst also, but regarded chemical work as somewhat tedious. His chief love was crystal measurement and drawing. This, I think, reflects his early interest in navigation and draughtsmanship. One of his achievements was to describe a new mineral from Broken Hill, which he very appropriately named sturtite after the great Australian explorer.

In addition to research, his period of office at the Museum was marked by a tremendous improvement in the display and storage of the Museum mineral collection. From 1925 until the time of his death he was Teacher of Mineralogy at the Sydney Technical College.

He was also very interested in gemmology and was unremitting in his efforts to instil into all concerned with the jewellery trade a strong regard for the scientific

aspects of their calling. The Gemmological Association of Australia, established within recent months, owes its origin, in part, to his pioneering work.

His scientific interests apart from these official duties were numerous. He was a Fellow of the Australian and New Zealand Association for the Advancement of Science and a Member of the Royal Society of New South Wales, the Museums and Art Galleries Association of Australia and New Zealand, and the Australian Association of Scientific Workers. From 1935 until 1941 he edited the Australian National Research Council's publication *Australian Science Abstracts*.

In later years additional administrative duties in the Museum and preoccupation with N.E.S. duties made necessary by the war situation at the time rather curtailed the time he could devote to research. Only a few weeks before his death he began a series of fresh investigations into meteorites which seemed to herald a period of research activity. Unfortunately this work was barely under way when he died, and remains to be completed.

No account of his life would be complete without mention of his sterling qualities as a fighter for the rights and privileges of the public servant. In the early twenties he took an active part in the Public Service Association of New South Wales, rising in 1933 to the high office of President of this large and important trade union, with a membership of some ten thousand. He occupied this office for three years. The strain was terrific. It was at a time when public servants were fighting for restoration of the salary cuts which had been taken from them at the beginning of the economic depression. The P.S.A., with Hodge-Smith at the helm, was in the forefront of this fight and he contributed in no small measure to the eventual success of the campaign.

He was also interested in the activities of the Institute of Public Administration. He had very decided views on the custom, so prevalent in our society, of having non-technical men as administrators of scientific activities either inside or outside the Public Service. His own career, indeed, afforded a shining example of how scientific and administrative ability are not mutually exclusive.

These many and varied activities illustrate his energy, determination and perseverance until a given object was attained. His relaxations and pastimes were few, or at least he seldom spoke of them. Yet the impression should not be gained that he was in any sense a forbidding personality. He had a characteristic sense of humour and could be most entertaining.

His sudden death on the 8th June, 1945, when only in his fifty-first year, has all too soon removed a prominent figure from the Australian world of science and has left those who were fortunate to count him as a colleague and friend poorer by his loss.

He is survived by Mrs. Hodge-Smith and two daughters.

Obituary notices utilized in writing the above are *The Australian Journal of Science*, vii, 6, 1945, and *Red Tape* (official organ of the Public Service Association of N.S.W.), June, 1945.

R.O.C.

List of Papers by T. Hodge-Smith.

1923.

Mineralogical Notes; No. 1. Rec. Aust. Mus., xiv, 2, 1923, 101–112.

1924.

Notes on the Occurrence of Zeolites, Ardglen, New South Wales. Rec. Aust. Mus., xiv, 3, 1924, 213–222.

Evidence of a Negative Movement of the Strand Line of 400 feet in New South Wales. *Journ. Roy. Soc. N.S.W.*, lviii, 1924, 157–168. (With T. Iredale.)

1926.

The "Ticraco Creek"* Siderite. Rec. Aust. Mus., xv, 1, 1926, 66–68. (With H. P. White.)

Mineralogical Notes; No. 2. Rec. Aust. Mus., xv, 1, 1926, 69–78.

1927.

Mineralogical Notes; No. 3. Rec. Aust. Mus., xv, 5, 1927, 313–320.

* Dr. E. S. Simpson (*Min. Mag.*, xxv, 1938, 163) has pointed out that the proper name of the locality after which this siderite is named is "Tieraco Creek", not "Ticraco Creek".

1929.

The Elsinora Meteorite; A New Chondrite from New South Wales. Rec. Aust. Mus., xvii, 1, 1929, 50–52.

The Occurrence of Zeolites at Kyogle, New South Wales. Rec. Aust. Mus., xvii, 6, 1929, 278–290.

1930.

Mineralogical Notes; No. 4. Rec. Aust. Mus., xvii, 9, 1930, 408–413.

1931.

The Narellan Meteorite: A New Chondrite from New South Wales. Rec. Aust. Mus., xviii, 5, 1931, 283–285.

1932.

The Weekeroo Meteorite: A Siderite from South Australia. Rec. Aust. Mus., xviii, 6, 1932, 312–313.

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Geological and Mineralogical Observations in Central Australia. Rec. Aust. Mus., xviii, 8, 1932, 415–442.

1934.

Mineralogical Notes; No. 5. Rec. Aust. Mus., xix, 3, 1934, 165–176.

1937.

An Unrecorded Meteorite from Coolac, New South Wales. Rec. Aust. Mus., xx, 2, 1937, 130–132.

1939.

Australian Meteorites. *Mem. Aust. Mus.*, No. VII, 1939, pp. 84, 19 plates.

1941.

The Tawallah Valley Meteorite. Rec. Aust. Mus., xxi, 1, 1941, 1–8. (With A. B. Edwards.)

1942.

The Moorleah Meteorite. *Rec. Queen Victoria Museum, Launceston*, i, 1, 1942, 13–16. (With R. O. Chalmers.)

1943.

Mineralogical Notes; No. 6. Rec. Aust. Mus., xxi, 4, 1943, 244–256.

In addition he contributed twenty-eight popular science articles to the *Australian Museum Magazine.*

FOSSIL MURRAY COD (*MACCULLOCHELLA MACQUARIENSIS*) FROM DIATOMACEOUS EARTHS IN NEW SOUTH WALES.

By E. S. Hills.

(Plates xxxi-xxxiii.)

Introduction.

The fossil fishes described in this paper have been gathered together from various sources, and I am indebted to the following persons for the loan of specimens and for other facilities of research: Mr. Heber Longman, Director of the Queensland Museum, who first brought the occurrence of the beautifully preserved fishes from Bugaldi to my notice; Dr. Ida Brown, who subsequently discussed the occurrence with me and arranged for me to borrow the material in the Museum of the Geology Department, University of Sydney; Dr. A. B. Walkom, Director of the Australian Museum, who kindly loaned the specimens in his care, and also enabled me to examine material of the living Murray Cod; Miss E. C. Pope, of the Australian Museum, who supplied measurements and scales of the living species; Mr. J. A. Tubb, M.Sc., of the Fisheries Division, Council for Scientific and Industrial Research, who generously placed at my disposal his unpublished notes on anatomical variation within the genus *Maccullochella*; Mr. G. Mack, formerly of the National Museum, Melbourne, who provided material for comparison; Mr. R. A. Keble, of the National Museum, who loaned a fossil specimen in his care; Mr. H. F. Whitworth, Curator of the Mining Museum, Sydney, who kindly had certain fossil specimens photographed for me and loaned an important specimen for study; Mr. F. S. Colliver and Mrs. Fenton Woodburn, of Melbourne, who loaned specimens from their private collections. The photographs for the plates are the work of Miss M. Johnston, of the Geology Department, University of Melbourne.

The registered material studied by me is as follows:

1. Queensland Museum. No. F.2732. Loc., Baradine, Warrumbungle Mts., N.S.W.
2. Department of Geology, University of Sydney. Nos. 954, 979, 980, 956, 955. Loc., Bugaldi, 14 miles N.W. of Coonabarabran, N.S.W.
3. Australian Museum, Sydney. Nos. F.19324, 5; F.19799, F.30912, F.37085. Loc., Bugaldi. No. F.36921. Loc. Chalk Mt., near Coonabarabran. No. F.18259. Loc. Cooma, N.S.W.
4. Mining Museum, Sydney. No. F.12462. Loc. Bugaldi.—This specimen has been transferred to the Australian Museum Collection, where its registered number is F.42458.

With the exception of the specimen No. F.18259 from Cooma, it appears that all the other material was derived from the well-known deposit of diatomaceous earth at Chalk Mountain, Bugaldi, in the Warrumbungle area, regarding which Kenny (1924) states that "fossil fish and leaves are fairly plentiful". The fishes are beautifully laid out in the diatomite, with the bones but little disturbed and the finest details of the fin-lobes and scales preserved in impression. The bone, if present, is generally extremely friable except in one specimen (No. F.30912), in which both bone and scales are preserved.

All the specimens seen by me clearly belong to the one species, preliminary restorations based on this assumption having been confirmed by the study of material acquired later. No specimen is complete, and most are deficient as to head and tail.

The two most nearly complete examples, No. 954, of the Geology Department, University of Sydney, and No. F.12462 of the Mining Museum, afford most of the essential information and are designated as hypotypes.

Technical Description.

Family MACCULLOCHELLIDAE.

Genus MACCULLOCHELLA Whitley, 1929.

Rec. Austr. Mus., xvii, 3, June 27, 1929, p. 109, *nom. nov. pro Oligorus* Günther, preoccupied.

Maccullochella macquariensis (Cuvier and Valenciennes), 1829. *Hist. Nat. Poiss.*, iii, April, 1829, p. 58.

Head and Opercules.—(i) No. 954 (Pl. xxxi, fig. 1). Maxilla exposed, with supplemental bone; both dentaries are exhibited in the specimen, the right being displaced downwards from the symphysis; teeth villiform; head slightly depressed; orbit placed centrally over distal end of maxilla.

(ii) No. 979 (Pl. xxxiii, fig. 1). Opercules thin; operculum with a single weak spine; pre-operculum entire.

(iii) F.36921 (Pl. xxxii, fig. 1). Transverse ridge on frontals posteriorly, connecting the parietal crests; occipital crest feeble, not extending to the frontals.

Vertebrae (Pls. xxxi–xxxiii).—Specimens F.2732, F.19325 and 956 show 20 caudal vertebrae. The number of abdominal vertebrae is difficult to determine, and only one specimen, No. 954, gives a reliable count, showing 15. Five other specimens show at least 13, with the additional anterior vertebrae obscured.

Dorsal Fin (Pls. xxxi–xxxiii).—At least 10, possibly 11 spines (954, F.19325), soft dorsal with 14 (954), 15 (956, 980) or 16? (F.42458) rays.

Anal Fin (Pl. xxxii).—Spines 3, Nos. 1 and 2 crossing (F.36921, F.19799); soft part with at least 11 rays, possibly averaging 12 (956, 979, F.19325, F.30921, F.37085).

Caudal Fin (Pls. xxxi–xxxiii).—Margin rounded, rays about 17 (F.42458, and specimen from Nat. Mus., Melbourne).

Ventral Fin (Pl. xxxii, fig. 1).—One spine, 5 soft rays (979, and specimen from Mrs. Woodburn).

Pectoral Fin (Pl. xxxii, fig. 1).—Rounded, with numerous rays (F.42458, 956, 979).

Scales.—Small, with well-marked ctenoid area. The cyclic ornament is dominant in impressions of overlapping scales, but in F.30912 the actual scales are preserved and the rather weak radii are clearly displayed.

General.—The characteristics of the form, including the lobation of the fins, sculpture of vertebrae and proportions of the body, may be gathered from the illustrations.

Identification.

The general resemblance of the remains to the Murray Cod *Maccullochella macquariensis* (Cuvier and Valenciennes) was obvious after a preliminary restoration had been made. There were, however, many important differences between the fossils and the reported details of the osteology of *Maccullochella* given by McCoy (1884) and Boulenger (1895), which suggested that the fossils were perhaps not even congeneric with *Maccullochella*. The main differences are as follows:

Murray Cod (as described).	*Fossils.*
Skull.—Strongly depressed anteriorly. Eye placed well forward of distal end of the maxilla.	Not strongly depressed. Eye placed above distal end of the maxilla.
Spinose dorsal.—XI spines, very small compared with depth of body and height of soft dorsal.	X or ?XI spines of moderately large size, about equal to height of soft dorsal.
Vertebrae.—Boulenger gives 16A and 19C.	Fossils show 15A and 20C.

It should be noted that all the fossils from which significant osteological details were obtained were small fishes, averaging 10 to 11 inches in length, whereas the descriptions of Murray Cod in the literature are based on specimens averaging between 2 feet and 3 feet 6 inches in length, and ranging up to 6 feet. Being aware of significant changes in the relative proportions of the various parts of the anatomy of fishes during growth, especially among forms exhibiting giantism, such as *Maccullochella*, I studied the excellent collection of small Murray Cod in the Australian Museum, and also obtained from Mr. J. A. Tubb, of the Fisheries Division of the Council for Scientific and Industrial Research, much valuable unpublished information on the osteological

characteristics of the genus, which he has demonstrated to be remarkably plastic. The examination of the small specimens was quite sufficient to show that the fossils are indistinguishable from such immature examples of *Maccullochella macquariensis*, the differences listed above as to shape of skull, position of eye, and relative size of the spines in the spinose dorsal all disappearing. Mr. Tubb's data show that the number of spines in the spinose dorsal varies between 10 and 12, and, in fact, the number of rays in the several fins in the fossils lies within the range of variation of *Maccullochella macquariensis*. Furthermore, a small specimen of the species dissected by me has 21 caudal and 14 abdominal vertebrae. It will thus be seen that the total number of vertebrae (35) is apparently constant, but that the ratio of abdominal to caudal vertebrae may range from 16:19 according to Boulenger; 15:20 in the fossils; and 14:21 in the above-mentioned specimen. I have, therefore, referred the remains to the living species.

Remarks.

The small size of the fossils calls for some comment. The largest specimen is incomplete, but is estimated to represent a fish nearly 2 feet long; the average length is only 10–11 inches. In spite of their perfect preservation with even the squamation largely intact, there is no trace of stomach contents in any specimen, and it seems very probable that the supply of food was inadequate. No fossils other than these fish, dicotyledonous plant remains, and the diatom tests and *Spongilla* spicules of the diatomaceous earths themselves have been recorded from the deposits. It may therefore be that the fishes died of starvation on attaining a certain relatively small size.

On the other hand, it may be that a single invasion of Murray Cod into the diatomaceous lake was killed by an accession of hot volcanic spring water. David (1896), in discussing the origin of the diatomaceous earths in the area, comments on their close association with Tertiary volcanic rocks, which association, it may be noted, is also found in other parts of eastern Australia, including Queensland and Victoria.

The single specimen from Cooma (F.18259) is a caudal fragment indistinguishable from the remains from Chalk Mountain. This, of course, is not an indication that the deposits at these two widely separated localities are of the same age, but the interesting physiographic implication is that the diatom-bearing lakes at each place were connected with a river system in which Murray Cod existed. It is also worthy of note that no fish remains have so far been discovered in the Cainozoic diatomaceous earths of Queensland or Victoria, although many deposits have been opened up in those States. The indications are, therefore, that the former distribution of the species was similar to the present, that is, mainly in the Murray River system. This being the first record of fossil Murray Cod, the remains are of little value for age-determination, but since the living species is represented, the first presumption would be that the remains are not older than Pliocene, which is the period to which David finally assigned the deposits in the Warrumbungle Mountains (1932). The evidence of age provided by the fishes is, however, not decisive.

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EXPLANATION OF PLATES.

Fossil *Maccullochella macquariensis* (C. & V.), Bugaldi, N.S.W.

Plate xxxi.—1. (F.42459) 954, Department of Geology, University of Sydney. Hypotype. 2. F.42458, Australian Museum, Sydney. Hypotype.

Plate xxxii.—1. F.36921, Australian Museum, Sydney. Note dorsal view of posterior part of skull. 2. 956, Department of Geology, University of Sydney.

Plate xxxiii.—1. 979, Department of Geology, University of Sydney. Shows ventral fins, pectoral fins, and opercular apparatus. 2. Caudal fin, specimen in National Museum, Melbourne.

Miss M. Johnston, photos.

ON THE OCCURRENCE OF *ALEPAS PACIFICA* PILSBRY IN TASMANIA.

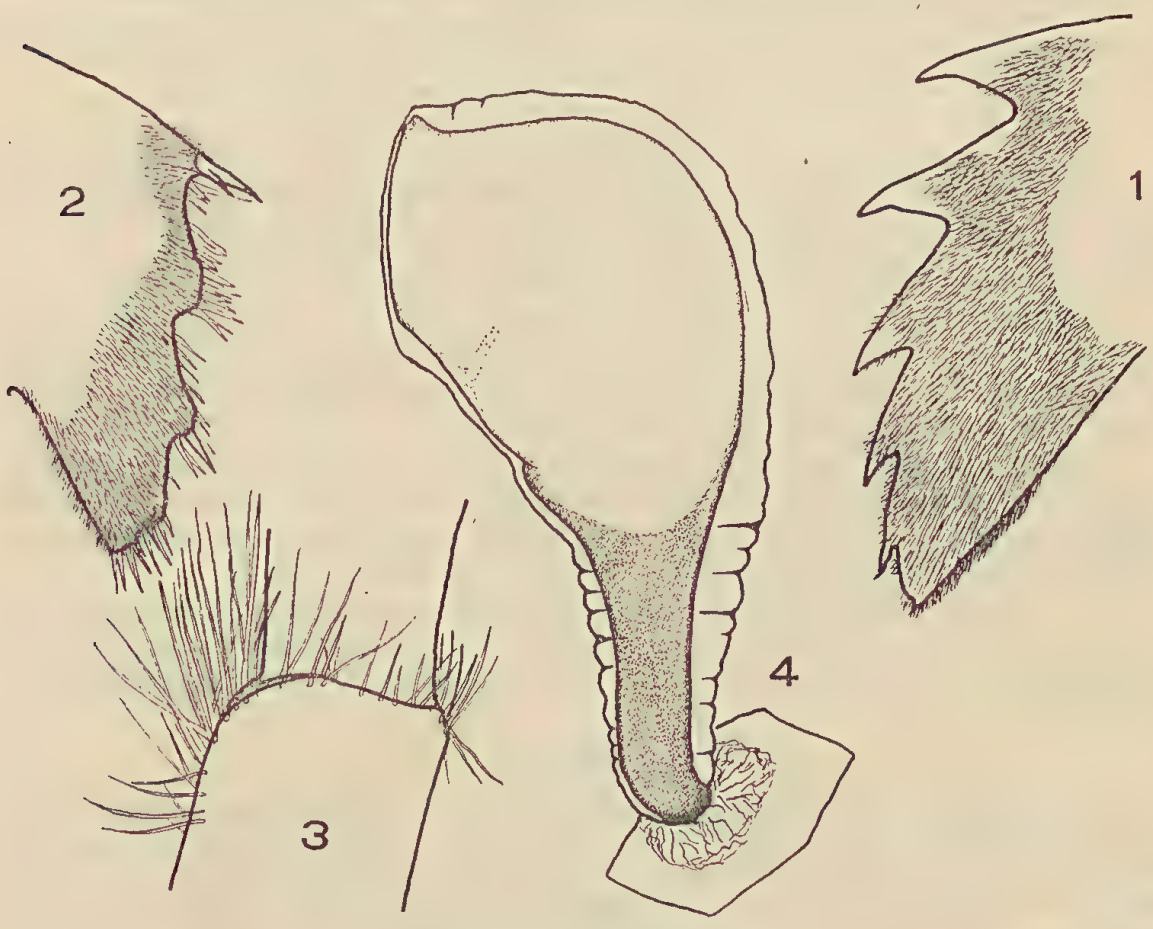
By J. Alan Tubb.

During the course of biological investigations for C.S.I.R. Fisheries Division, an officer of the Division collected several medusae in Marion Bay, on the east coast of Tasmania. These medusae (*Cyanea capillata* var. *annaskala* von Lendenfeld) were found to carry on the fringe and upper surface of the umbrella, a number of nude pedunculate barnacles, which correspond anatomically with Pilsbry's description (1907) of *Alepas pacifica*. The distribution of the species and its host relationship are discussed.

Description.

Dissection of the largest specimen revealed a close similarity with the description and figures given by Pilsbry, except that the mandible and maxilla were finely pubescent all over (Figs. 1 and 2), in this agreeing with the figures given by Nilsson-Cantell (1921, tf. 42).

The penis differs from Pilsbry's figure (1907, Pl. V, fig. 6), being long and slender, subequal to the sixth cirrus in length and apparently lacking the fine annulation.



Figs. 1-4. *Alepas pacifica.*
1, Mandible. 2, Maxilla. 3, Setation of 6th cirrus. 4, External appearance.
J.A.T. del.

The setation of the cirri differs in some degree from Pilsbry's figure (1907, tf. 34 C), there being no gap between the posterior and anterior clumps on each segment (Fig. 3). The gap is bridged by a single row of setae. Hiro (1937) demonstrates the presence of six filamentary appendages in Japanese specimens. The Tasmanian specimens also show these filamentary appendages, the first being apparently longer than in Hiro's example.

In life the barnacles were translucent white, the visceral mass appearing through the integument as a dull purple-grey. Large egg-masses are present in three specimens, forming loose sheaths partly enveloping the body mass within the integument of the capitulum. These egg-masses are pale yellow and opaque. The eggs, after preservation for eight months in formalin, are oval and measure approximately 0·19 mm. × 0·11 mm. The eggs are enveloped in pockets in an extremely delicate membrane which binds the mass together.

Seven specimens referable to *Alepas pacifica* were collected in Marion Bay in January, 1945 (Nos. P.11651–2, Aust. Museum).

Dimensions.	I.	II.	III.	IV.	V.	VI.	VII.
	mm.	mm.	mm.	mm.	mm.	mm.	mm.
Capitulum, length	23·0	20·5	18·0	17·0	15·5	12·0	9·0
„ width	17·0	16·0	12·0	12·0	10·0	8·0	6·0
Peduncle, length	14·0	14·0	11·5	8·0	11·0	6·5	5·5
„ width	7·5	6·0	5·0	5·0	4·0	3·5	3·0

Specimens I (P.11651, dissected and figured), III and IV carried egg-masses.

The barnacles were firmly attached, at the base of the peduncle, to the fringe and upper surfaces of the umbrella of medusae referable to *Cyanea capillata* var. *annaskala* von Lendenfeld. The site of attachment was wrinkled and slightly depressed.

Distribution.

Originally described from the north of San Francisco, California, by Pilsbry (1907), *Alepas pacifica* was later recorded from Pacific Grove, California, by Nilsson-Cantell (1925), and by the same author from 6° 19′ S. Lat., 110° 50′ E. Long., in the Java Sea, between Java and Borneo. Hiro (1937) records the species from southern Honshu.

Annandale's species, *A. investigatorius* (1914), placed by Nilsson-Cantell in the synonymy of *Alepas pacifica*, was obtained in Morrison Bay, Mergui Archipelago. The sole record of this species outside the Indo-Pacific and Pacific areas is given by Nilsson-Cantell (1921, p. 445) as "southern Atlantic Ocean".

From the evidence available it appears that the seas of the Malay Archipelago northwards to Japan may be the stronghold of the species, and it is regrettable that Pilsbry's diagnoses (1912) of *A. navigator* and *A. spectrum* from Nogas Pt. in the Philippine Islands are insufficiently detailed to allow adequate comparison.

The discovery of the species in Tasmanian waters amply justifies Pilsbry's remark (1907, p. 106) that "the essential pelagic habit of the genus leads us to anticipate wide dispersion of the species, limited only by the distribution of the medusae which serve as their hosts".

Host Medusae.

The literature generally lacks specific mention of the medusae to which this interesting barnacle adheres, until Hiro (1937) listed *Pelagia panopyra* Peron and Lesueur, *Cyanea nozakii* Kishinouye, *Cephea cephea* (Forskal); Annandale (1914), stated that his specimen came from a rhizostomous medusa. Nilsson-Cantell (1934), p. 39, supplemented his record of *Alepas pacifica* from the Java Sea with the note "the notice on the label that the specimens are taken from spines of cidarids seems to me to be erroneous".

The association of the Tasmanian specimen of *Alepas pacifica* with *Cyanea capillata* var. *annaskala* demonstrates the possibility of an interesting chain of distribution and association. *C. capillata* var. *annaskala* recorded from the coastal waters of New South Wales, Victoria, South Australia, Tasmania (Blackburn, MS.), and possibly (Mayer, 1910, p. 602) from South Africa (*Desmonema annasethe*, Haeckel, 1880), is the southern representative of the *Cyanea capillata* group of which *C. nozakii* is, according to Mayer (1910, p. 601), a colour variety from Japanese waters. *C. capillata* var. *ferruginea*, and *C. capillata* var. *postelsii* appear to be the eastern Pacific representatives. *Pelagia panopyra*, Peron and Lesueur, is widely distributed through the tropical Pacific, and *Cephea cephea* (Forskal) also is widely distributed through typical Indo-Pacific waters.

Admittedly the evidence so far adduced is far from complete, but it appears probable that a definite host chain exists from the coastal *C. capillata* in the North Pacific, through the pelagic *Pelagia panopyra* and *Cephea cephea* of tropical Pacific and Indo-Pacific seas, to the coastal *C. capillata* var. *annaskala* of southern Australia.

I am indebted to Mr. W. Fairbridge for the specimens discussed herein, and to Mr. M. Blackburn for the identification of the medusae.

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A LIST OF THE TYPES AND PARATYPES OF BIRDS FROM AUSTRALIAN LOCALITIES IN THE AUSTRALIAN MUSEUM, SYDNEY, NEW SOUTH WALES.

By K. A. Hindwood.

The following notes have been prepared with the object of placing on record, for future workers in taxonomy and nomenclature, the types and paratypes (or co-types) of birds from localities within Australia at present in the Australian Museum, Sydney. It is, so far as I am aware, a complete list. Particulars in the Museum registers and on labels attached to the specimens have been compared with published details accompanying the original descriptions of the specimens. Relevant facts, especially concerning type localities, have been included under the respective names.

The name proposed for a particular specimen, or a series of specimens, is given, together with a reference to the original description. This is followed by the registered number of the specimen and pertinent data. The present status of the names according to the *Official Checklist* of the Royal Australasian Ornithologists' Union, second edition, 1926, and the *Systema Avium Australasianarum*, Gregory M. Mathews, 1927–1930, is then given. Explanatory notes have been added where necessary. Many of the names based on the specimens listed have since been placed in synonymy, or used tri-nomially to designate subspecies.

Earlier workers in ornithology frequently marked each of a series of skins as "type", or "one of the types". In several instances it was found that actual type material had been placed in the general reference collection. Only when the particulars of such specimens (locality, date, *et cetera*) agree with the published data have they been transferred to the type drawer.

In cases where more than a single specimen has been the basis of a name and the author has not indicated a type specimen I have selected a type, or the types of the male and female, and shown this by placing the word "(selected)" after the specimen or specimens.

Included among the type skins are two specimens of a flycatcher (Nos. O.349, O.350) from Derby, north Western Australia, bearing the manuscript name of *Microeca axillaris* Ramsay. Both skins are marked as types by Ramsay. A. J. North later added a note on the label to the effect that he had compared these specimens with the type of *M. pallida* De Vis, with which they agreed. The species represented is the Brown Flycatcher *M. fascinans* of the R.A.O.U. *Checklist* and *M. leucophaea pallida* of the *Systema Avium Australasianarum.*

A third specimen to which a manuscript name is attached is No. O.12859, from Cooktown, north Queensland, presented by E. C. A. Olive in 1902. North has written on the label "*Ninox oliverii*, type". The skin is that of the Rufous Owl, *N. rufa* of the R.A.O.U. *Checklist*, and *Rhabdoglaux rufa queenslandica* of the *Systema Avium Australasianarum.*

The Australian Museum also possesses a number of type specimens of birds from such localities as New Guinea, New Ireland, the Solomons, Fiji, New Hebrides, Lord Howe Island, and Henderson or Elizabeth Island (Paumotu Group or Low Archipelago).

The most interesting specimen amongst those listed is undoubtedly a paratype of *Amytornis goyderi*, the Eyrean Grass-Wren. It is the third known specimen of that species and was collected near Lake Eyre, central Australia, in December, 1874. Detailed

notes on this skin have recently been published in *The Emu* (Vol. xliv, Pt. 4, April, 1945, p. 323).

The following corrections to the R.A.O.U. *Checklist*, and the *Systema Avium Australasianarum*, will be necessary. *Poëphila aurantiirostris* North should be quoted from *Linnean Society of New South Wales, Abstract of Proceedings*, May 28, 1902, p. 4; a more extended notice appears in the *Proceedings* of this Society, Vol. xxvii, Part 2, October 17, 1902, p. 208. The page reference to *Calamanthus albiloris* should be 102, not 106. The page reference to *Scenopoeus dentirostris* Ramsay should be 591, not 491, in *Systema Avium Australasianarum*.

TURNIX LEUCOGASTER North, *The Ibis* (7), i, 3, July, 1895, p. 342.
Type: O.9162, ♀, Davenport Creek, central Australia (Horn Expedition).
T. velox, Little Quail (*R.A.O.U.*, p. 4).
Alphaturnia velox leucogaster (*Syst. Av. Austr.*, p. 24).

CHALCOPHAPS OCCIDENTALIS North, *Vic. Natur.*, xxiv, 8, December, 1907, p. 135.
Paratype: O.16012, Port Keats, n.w. Australia.
C. chrysochlora, Green-winged Pigeon (*R.A.O.U.*, p. 7).
C. c. longirostris (*Syst. Av. Austr.*, p. 66).

CINATHISMA CYANEOLEUCA Hull, *The Emu*, xv, 3, January, 1916, p. 205, pl. 32.
Paratypes: O.24063, O.24064, off Brush Island, south of Ulladulla, N.S.W., December, 1915.
Puffinus gavia, Fluttering Shearwater (*R.A.O.U.*, p. 12).
Reinholdia gavia byroni (*Syst. Av. Austr.*, p. 112).

AEGIALITIS MASTERSI Ramsay, *Proc. Linn. Soc. N.S.W.*, i, 2, July, 1876, p. 135.
Type: O.18587, ♂, Cape York, Queensland.
Paratype: O.18596, ♀.
Charadrius mongolus, Mongolian Sand-Dotterel (*R.A.O.U.*, p. 23).
Cirrepidesmus mongolus mongolus (*Syst. Av. Austr.*, p. 158).
The above specimens represent the Mongolian Sand-Dotterel in breeding plumage; they are labelled, in Ramsay's handwriting, types of the male and female respectively. Ramsay described the male only; the female is listed above as a paratype. The differences in plumage between the two specimens are very slight.

NINOX YORKI Cayley, *The Emu*, xxviii, 3, January, 1929, p. 162, pl. 34 (top fig.).
Type: O.27647, Cape York Peninsula, n.e. Queensland.

NINOX OOLDEAENSIS Cayley, *The Emu*, xxviii, 3, January, 1929, p. 163, pl. 34 (lower fig.).
Type: O.26604, ♀, 407 miles, East-West Line, South Australia, Oct. 3, 1921.

NINOX CONNIVENS OCCIDENTALIS Ramsay, *Proc. Linn. Soc. N.S.W.* (2), i, 4, February 22, 1887, p. 1086.
Type (selected): O.329, Derby, n.w. Australia, 1885.
N. connivens, Winking Owl (*R.A.O.U.*, p. 41).
Hieracoglaux connivens occidentalis (*Syst. Av. Austr.*, p. 276).

TYTO NOVAE-HOLLANDIAE TROUGHTONI Cayley, *What Bird is That?*, November 27, 1931, p. 32, pl. 5 (fig. 4).
Type: O.26568, ♀, Ooldea, East-West Line, Oct. 16, 1921.

CYCLOPSITTA MACLEAYANA Ramsay, *Proc. Zool. Soc.* (Lond.), pt. 4, April 1, 1876, p. 602.
Types: O.18582, ♂; O.18583, ♀, Cardwell, Queensland, July, 1874.
Paratype: O.18584, ♂.
Opopsitta leadbeateri, Blue-faced (Red-browed) Lorilet (*R.A.O.U.*, p. 43).
O. leadbeateri (*Syst. Av. Austr.*, p. 304).

SPATHOPTERUS North, *The Ibis* (7), i, 3, July, 1895, p. 339.
Type of the genus, O.9163, ♂, Glen Edith, Central Australia (Horn Expedition).
Type (by monotypy) *Polyteles alexandrae* Gould.
Polytelis alexandrae, Princess Parrot (*R.A.O.U.*, p. 46).
Northipsitta alexandrae (*Syst. Av. Austr.*, p. 330).
The above specimen figured in *Report Horn Expedition*, pt. 2, Zoology, 1896, pl. 5.

PLATYCERCUS PENNANTI var. NIGRESCENS Ramsay, *Tab. List. Austr. Birds*, 1888, p. 34.
Type: O.1953, Bellenden Ker Range, Queensland, Feb., 1888.
P. elegans, Crimson Rosella (*R.A.O.U.*, p. 47).
P. e. nigrescens (*Syst. Av. Austr.*, p. 338).

PLATYCERCUS DIEMENENSIS North, *Austr. Mus. Spec. Cat.*, No. 1, iii, 2, July 27, 1911, p. 128.
Type: A.6533, ♂, Tasmania.
P. eximius, Eastern Rosella (*R.A.O.U.*, p. 47).
P. e. diemenensis (*Syst. Av. Austr.*, p. 341).

PLATYCERCUS MASTERSIANUS Ramsay, *Proc. Linn. Soc. N.S.W.*, ii, 1, July, 1877, p. 27.
Type: O.23688, N.S.W. (interior).
A. J. North has written on a label attached to this specimen the following remarks: "This specimen is undoubtedly a hybrid between *Platycercus palliceps* [= *P. adscitus*] and *P. elegans*, or an unusually plumaged specimen of the latter." A similarly plumaged bird is figured in the *Proc. Zool. Soc.* (*London*), vol. 1, 1902, pl. xix, see p. 170.

PLATYCERCUS MACGILLIVRAYI North, *Vic. Natur.*, xvii, 5, Sept., 1900, p. 91.
Type: O.11837, Leilavale Station, Cloncurry River, Burke District, north Queensland.
Barnardius macgillivrayi, Cloncurry Parrot (*R.A.O.U.*, p. 48).
B. macgillivrayi (*Syst. Av. Austr.*, p. 342).

PLATYCERCUS OCCIDENTALIS North, *Rec. Austr. Mus.*, ii, 5, September, 1893, p. 83.
Type: O.3313, ♀, 36 miles s.w. of Roeburne, mid-west Australia, October 1889.
Paratype: O.3312, ♀.
Barnardius zonarius, Port Lincoln Parrot (*R.A.O.U.*, p. 48).
B. z. occidentalis (*Syst. Av. Austr.*, p. 343).

PSEPHOTUS CUCULLATUS North, *Vic. Natur.*, xxv, 11, March, 1909, p. 176.
Types: O.16238, ♂; O.16239, ♀; Pine Creek, Northern Territory, February 2, 1909.
P. dissimilis, Hooded Parrot (*R.A.O.U.*, p. 49).
Psephotellus dissimilis (*Syst. Av. Austr.*, p. 346).

PEZOPORUS FLAVIVENTRIS North, *Austr. Mus. Spec. Cat. No. 1*, iii, 2, July 27, 1911, p. 175.
Type: O.23687, ♂, King George's Sound, Western Australia, April, 1866.
P. wallicus, Ground Parrot (*R.A.O.U.*, p. 51).
P. w. flaviventris (*Syst. Av. Austr.*, p. 353).

ALCYONE RAMSAYI North, *The Ibis* (9), vi, 21, January, 1912, p. 119.
Type: A.4606, ♂, Port Essington, Northern Territory, February, 1879.
A. pusilla, Little Kingfisher (*R.A.O.U.*, p. 52).
Micralcyone pusilla ramsayi (*Syst. Av. Austr.*, p. 367).

CYPSELUS TERRAE-REGINAE Ramsay, *Proc. Zool. Soc.* (Lond.), pt. 4, April 1, 1875, p. 601.
Types: O.18480, ♂, O.18481, ♀, Rockingham Bay, near Cardwell, Queensland.
Collocalia francica, Grey Swiftlet (*R.A.O.U.*, p. 55).
C. f. terraereginae (*Syst. Av. Austr.*, p. 400).

RHIPIDURA ALBICAUDA North, *The Ibis* (7), i, 3, July, 1895, p. 340.
Type: O.9153, ♂, Stokes Pass, central Australia (Horn Expedition).
R. flabellifera, Grey Fantail (*R.A.O.U.*, p. 60).
R. f. albicauda (*Syst. Av. Austr.*, p. 482).
The above specimen figured in *Report Horn Expedition*, pt. 2, Zoology, 1896, pl. 6 (bottom fig.).

RHIPIDURA INTERMEDIA North, *Vic. Natur.*, xix, 7, November, 1902, p. 101.
Type: O.2049, ♂, Boar Pocket, about 30 miles from Cairns, Bellenden Ker Range, north Queensland.
R. rufifrons, Rufous Fantail (*R.A.O.U.*, p. 60).
R. r. intermedia (*Syst. Av. Austr.*, p. 487).

RHIPIDURA SUPERCILIOSA Ramsay, *Proc. Zool. Soc.* (Lond.), pt. 4, April 1, 1875, p. 604.
Type: O.18578, ♂, Endeavour River, Rockingham Bay, Queensland, 1874.
R. setosa, Northern Fantail (*R.A.O.U.*, p. 60).
Setosura rufiventris superciliosa (*Syst. Av. Austr.*, p. 492).

POECILODRYAS ? CINEREIFRONS Ramsay, *Proc. Zool. Soc.* (Lond.), pt. 4, April 1, 1876, p. 588.
Type: O.18577, ♂, Dalrymple's Gap, near Cardwell, Queensland, 1874.
Type of the genus *Heteromyias* Sharpe, *Cat. Birds Brit. Mus.*, Vol. 4, 1879, pp. 114, 239. Type (by monotypy) *Poecilodryas cinereifrons* Ramsay.
Heteromyias cinereifrons, Grey-headed Robin (*R.A.O.U.*, p. 64).
Iredaleornis cinereifrons (*Syst. Av. Austr.*, p. 470).
Sharpe founded the genus *Heteromyias* on the above specimen which was sent to him by Ramsay. This specimen is also the basis of Gould's plate in the *Birds of New Guinea* (ii, 10, Sept. 1, 1879, pl. 15), wherein the bird is figured in two positions. The plate is somewhat overcoloured.

EOPSALTRIA MAGNIROSTRIS Gould, *Ann. Mag. Nat. Hist.*, (4), iv, August 1, 1869, p. 109; ex Ramsay, *Proc. Zool. Soc.* (Lond.), pt. 2, September 15, 1868, p. 384.

Type: O.18576, ♂, Cardwell, Queensland, 1867.

E. chrysorrhoa, Northern Yellow Robin (*R.A.O.U.*, p. 65).

E. australis magnirostris (*Syst. Av. Austr.*, p. 684).

EOPSALTRIA NANA Ramsay, *Proc. Linn. Soc. N.S.W.*, ii, 4, June, 1878, p. 372.

Type: O.18588, ♀, Cardwell, Queensland, collected K. Broadbent, 1874.

E. capito, Pale Yellow Robin (*R.A.O.U.*, p. 65).

Tregellasia capito nana (*Syst. Av. Austr.*, p. 476).

PACHYCEPHALA OCCIDENTALIS Ramsay, *Proc. Linn. Soc. N.S.W.*, ii, 2, January, 1878, p. 212.

Type: O.18570, ♀, Albany, Western Australia.

P. pectoralis, Golden Whistler (*R.A.O.U.*, p. 66).

P. p. occidentalis (*Syst. Av. Austr.*, p. 664).

Both sexes were described by Ramsay; I have been unable to trace the type of the male.

PACHYCEPHALA MERIDIONALIS North, REC. AUSTR. MUS., v, 2, January 28, 1904, p. 126.

Type: O.987, ♂, hills near Adelaide, coll. June, 1887.

P. pectoralis, Golden Whistler (*R.A.O.U.*, p. 66).

P. p. fuliginosa (*Syst. Av. Austr.*, p. 664).

PACHYCEPHALA PALLIDA Ramsay, *Proc. Linn. Soc. N.S.W.*, ii, 3, May, 1878, p. 224.

Types: O.18572, ♂, O.18573, ♀, Gulf of Carpentaria, near Georgetown, collected 16.6.1876.

P. rufiventris, Rufous Whistler (*R.A.O.U.*, p. 66).

P. r. pallida (*Syst. Av. Austr.*, p. 675).

EOPSALTRIA ? INORNATA Ramsay, *Proc. Zool. Soc.* (Lond.), April 1, 1875, p. 604.

Types: O.32614, ♂, O.18571, ♀, Cardwell, Queensland, collected K. Broadbent, 1874.

Pachycephala griseiceps, Grey Whistler (*R.A.O.U.*, p. 67).

Muscitrea griseiceps inornatus (*Syst. Av. Austr.*, p. 679).

COLLYRIOCINCLA CERVINIVENTRIS North, REC. AUSTR. MUS., iii, 2, August 5, 1897, p. 49.

Type: O.23685, Dawson River, Queensland.

Colluricincla megarhyncha, Rufous Shrike-Thrush (*R.A.O.U.*, p. 68).

Caleya megarhyncha cerviniventris (*Syst. Av. Austr.*, p. 648).

COLLYRIOCINCLA BOWERI Ramsay, *Proc. Linn. Soc. N.S.W.*, x, 2, July, 1885, p. 244.

Types: O.18568, ♂; O.18569, ♀, Peterson's Pocket, Cairns, n.e. Queensland, December 12 and 14, 1884.

Colluricincla boweri, Bower Shrike-Thrush (*R.A.O.U.*, p. 68).

Bowyeria boweri (*Syst. Av. Austr.*, p. 649).

The male only was described in the original description of the species; the sexes are alike in plumage. A label, in Ramsay's handwriting, on specimen No. O.18569, states: "Type of *C. boweri* female." On this basis it is listed as such.

PSOPHODES CREPITANS LATERALIS North, REC. AUSTR. MUS., iii, 1, January 7, 1897, p. 13.

Type: O.4645, ♂, Boar Pocket, about 30 miles from Cairns, Bellenden Ker Range, north Queensland, coll. May 4, 1891.

P. olivaceus, Eastern Whipbird (*R.A.O.U.*, p. 70).

P. o. lateralis (*Syst. Av. Austr.*, p. 563).

EPTHIANURA CROCEA Castelnau and Ramsay, *Proc. Linn. Soc. N.S.W.*, i, 4, March, 1877, p. 380.

Paratype: O.18589, ♀, Norman River, north Queensland.

E. crocea, Yellow Chat (*R.A.O.U.*, p. 74).

E. c. crocea (*Syst. Av. Austr.*, p. 587).

GERYGONE FLAVIDA Ramsay, *Proc. Linn. Soc. N.S.W.*, ii, 1, July, 1877, p. 53.

Types (selected): O.18590, ♂, O.18591, ♀, Herbert River, North Queensland, March, 1874.

Paratypes: O.18592, ♂, A.972, ♂, A.786, ♀.

G. flavida, Fairy Warbler (*R.A.O.U.*, p. 75).

Pseudogerygone flavida (*Syst. Av. Austr.*, p. 466).

For a full discussion on this species see "The Fairy Warbler: A Re-discovery", A. H. Chisholm, *The Emu*, xxiv, 3, January, 1925, pp. 161-5, pls. 24 (col.), 25.

GERYGONE PALLIDA North, *Austr. Mus. Spec. Cat No. 1*, i, 3, April 27, 1903, p. 196.

Type: O.3578, ♂, Boar Pocket, Bellenden Ker Range, North Queensland.

G. mouki, Northern Warbler (*R.A.O.U.*, p. 75).

Ethelornis mouki (*Syst. Av. Austr.*, p. 464).

GERYGONE SIMPLEX Masters, *Proc. Linn. Soc. N.S.W.*, i, 1, February, 1876, p. 52.
Paratype: O.18597, Norman River, Gulf of Carpentaria, Queensland.
G. levigaster, Buff-breasted Warbler (*R.A.O.U.*, p. 76).
Ethelornis m. mastersi (*Syst. Av. Austr.*, p. 464).

XEROPHILA NIGRICINCTA North, *The Ibis*, (7), i, 3, July, 1895, p. 340.
Types: O.9157, ♂; O.9155, ♀, Missionary Plain, central Australia (Horn Expedition).
Paratype: O.9156, ♂.
Aphelocephala nigricincta, Banded Whiteface (*R.A.O.U.*, p. 77).
A. n. nigricincta (*Syst. Av. Austr.*, p. 688).
Figured in *Report Horn Expedition*, pt. 2, Zoology, 1896, pl. 7 (top fig.).

ACANTHIZA MASTERSI North, *Agric. Gazette N.S.W.*, xii, 2, November, 1901, p. 1425.
Types: O.23684, ♂; O.13548, ♀; King George's Sound, Western Australia, coll. October and November, 1868.
A. inornata, Western Thornbill (*R.A.O.U.*, p. 78).
A. i. mastersi (*Syst. Av. Austr.*, p. 605).

ACANTHIZA WHITLOCKI North, *Vic. Natur.*, Vol. xxvi, 5, September 9, 1909, p. 55.
Type: O.16358, ♂, Lake Way, Western Australia, July 1, 1909.
A. whitlocki, Whitlock Thornbill (*R.A.O.U.*, p. 78).
A. pusilla whitlocki (*Syst. Av. Austr.*, p. 603).

ACANTHIZA ALBIVENTRIS North, *Austr. Mus. Spec. Cat. No. 1*, i, 4, July 11, 1904, p. 276.
Type: O.22917, ♂, Dubbo, N.S.W., collected Hearne, July, 1876.
A. albiventris, Inland Thornbill (*R.A.O.U.*, p. 79).
A. pusilla albiventris (*Syst. Av. Austr.*, p. 602).

SERICORNIS BRUNNEOPYGIUS Masters, *Proc. Linn. Soc. N.S.W.*, i, 1, February, 1876, p. 53.
Paratype: O.18601, Cape York, 1874.
S. minimus, Little Scrub-Wren (*R.A.O.U.*, p. 80).
S. minimus (*Syst. Av. Austr.*, p. 615).

OREOSCOPUS North, *Agric. Gazette, N.S.W.*, xvi, 3, March 2, 1905, p. 247.
Type of the genus; O.23686, Black Mountain, Bellenden Ker Range, north Queensland. Type (by monotypy), *Sericornis gutturalis* De Vis.
O. gutturalis, Fern-Wren (*R.A.O.U.*, p. 81).
O. gutturalis (*Syst. Av. Austr.*, p. 618).

CALAMANTHUS ALBILORIS North, *Vic. Natur.*, xix, 7, November, 1902, p. 102.
Type: O.23683, ♀, Victoria, 1865.
C. fuliginosus, Striated Field-Wren (*R.A.O.U.*, p. 82).
C. f. albiloris (*Syst. Av. Austr.*, p. 566).

CALAMANTHUS DIEMENENSIS North, *Austr. Mus. Spec. Cat. No. 1*, i, 4, July 11, 1904, p. 354.
Types (selected): O.12847 (♂ ?), Waratah, n.w. Tasmania, July, 1902; O.13251 (♀ ?), September, 1903.
Paratypes: O.12916, O.13249, O.13250.
C. fuliginosus, Striated Field-Wren (*R.A.O.U.*, p. 82).
C. f. anthoides (*Syst. Av. Austr.*, p. 566).
No details are available regarding the sexes of the above specimens. The types have been selected to agree with the descriptions published by North.

CALAMANTHUS ISABELLINUS North, *Rep. Horn Sci. Exped. Austr.*, pt. 2, Zoology. 1896, p. 85.
Types: O.9151, ♂, 0·9152, ♀, Missionary Plain, central Australia (Horn Expedition).
C. isabellinus, Rusty Field-Wren (*R.A.O.U.*, p. 82).
C. campestris isabellinus (*Syst. Av. Austr.*, p. 567).

EREMIORNIS CARTERI North, *Vic. Natur.*, xvii, 4, August, 1900, p. 79.
Type of the genus and species: O.11836, ♀, North-west Cape, near Exmouth Gulf, mid-west Australia, collected Tom Carter, 1.7.1899.
E. carteri, Spinifex-bird (*R.A.O.U.*, p. 83).
E. c. carteri (*Syst. Av. Austr.*, p. 600).

AMYTIS MODESTA North, *Vic. Natur.*, xix, 7, November, 1902, p. 103.
Type: O.23682, ♂, Meerenie Bluff, Macdonnell Ranges, central Australia.
Amytornis modestus, Thick-billed Grass-Wren (*R.A.O.U.*, p. 84).
A. m. modestus (*Syst. Av. Austr.*, p. 631).

AMYTIS GOYDERI Gould, *Ann. Mag. Nat. Hist.*, (4), xvi, October 1, 1875, p. 286.
Paratype: O.18596, ♂, Lake Eyre (Macumba River), Central Australia. December, 1874.
Amytornis goyderi, Eyrean Grass-Wren (*R.A.O.U.*, p. 84).
Eyramytis goyderi (*Syst. Av. Austr.*, p. 633).
See *The Emu*, xliv, 4, April, 1945, p. 323, for detailed remarks on the above specimen.

MALURUS AUSTRALIS North, *The Ibis*, (8), iv, 16, October, 1904, p. 672.
Type: O.9492, ♂, Meadowbank, near Sydney, August 2, 1897.
M. cyaneus, Superb Blue-Wren (*R.A.O.U.*, p. 86).
M. c. australis (*Syst. Av. Austr.*, p. 620).

MALURUS ASSIMILIS North, *Vic. Natur.*, xviii, 2, June, 1901, p. 29.
Type: A.11885, ♂, Mossgiel, western N.S.W., 1881.
M. assimilis, Purple-backed Wren (*R.A.O.U.*, p. 87).
Leggeornis lamberti assimilis (*Syst. Av. Austr.*, p. 623).

MALURUS CRUENTATUS BOWERI Ramsay, *Proc. Linn. Soc. N.S.W.*, (2), i, 4, February 22, 1887, p. 1100.
Type: O.18598, ♂ juv., Derby, inland, 1866.
M. melanocephalus, Red-backed Wren (*R.A.O.U.*, p. 88):
Ryania melanocephala bowerí (*Syst. Av. Austr.*, p. 627).

SITELLA ALBATA Ramsay, *Proc. Zool. Soc.* (Lond.), pt. 2, August 1, 1877, p. 351.
Type: O.18594, ♂, near Bowen, Port Denison, Queensland, collected J. Rainbird, 1864.
Neositta albata, Pied Sittella (*R.A.O.U.*, p. 89).
N. albata (*Syst. Av. Austr.*, p. 689).

NEOSITTA MORTONI North, *The Ibis*, (9), vi, 21, January, 1912, p. 118.
Types: A.4642, ♂; A.4644, ♀, Port Essington, N.T., 17.2.1879.
Paratype: A.4643, ♂.
N. leucoptera, White-winged Sittella (*R.A.O.U.*, p. 90).
N. l. leucoptera (*Syst. Av. Austr.*, p. 690).

SITELLA STRIATA Gould, *Birds Austr.*, Suppl., pt. 5, August 1, 1869, pl. 54; and *Ann. Mag. Nat. Hist.*, (4), iv, August 1, 1869, p. 110.
Paratype: O.18599, ♂, Cape York, Queensland.
Neositta striata, Striated Sittella (*R.A.O.U.*, p. 90).
N. s. striata (*Syst. Av. Austr.*, p. 691).
The above specimen is labelled "Original specimen, collected Cockerell and Thorpe, received March, 1861", and is, presumably, a paratype of the species.

CLIMACTERIS LEUCOPHAEA MINOR Ramsay, *Tab. List Austr. Birds*, 2nd ed., add., p. 2, after June 1, 1891.
Type (selected): O.37536, Scrubby Creek, Cairns, Queensland, collected T. H. Bowyer-Bower, January 8, 1885.
C. minor, Little Tree-creeper (*R.A.O.U.*, p. 91).
Cormobates minor (*Syst. Av. Austr.*, p. 695).

CLIMACTERIS SUPERCILIOSA North, *The Ibis*, (7), i, 3, July, 1895, p. 341.
Type: O.9160, ♂, Illara Creek, central Australia (Horn Expedition).
C. affinis, White-browed Tree-creeper (*R.A.O.U.*, p. 91).
Cormobates a. affinis (*Syst. Av. Austr.*, p. 695).
The above specimen figured in *Report Horn Expedition*, pt. 2, Zoology, 1896, pl. 7 (bottom figure).

PARDALOTUS ASSIMILIS Ramsay, *Proc. Linn. Soc. N.S.W.*, ii, 2, January, 1878, p. 180.
Type (selected): O.18593, Macquarie Fields, 30 miles s.w. of Sydney, N.S.W.
P. ornatus, Red-tipped Pardalote (*R.A.O.U.*, p. 92).
P. striatus ornatus (*Syst. Av. Austr.*, p. 723).
On the label attached to this specimen is written, in Ramsay's handwriting, *"Pardalotus assimilis*, sp. nov., Macquarie Fields", with a reference to the source of the original description. The specimen agrees with the meagre type description.

MELITHREPTUS LAETIOR Gould, *Ann. Mag. Nat. Hist.*, (4), xvi, October 1, 1875, p. 287.
Paratype: O.18567, ♂, Lake Eyre, central Australia.
M. laetior, Golden-backed Honeyeater (*R.A.O.U.*, p. 94).
M. l. laetior (*Syst. Av. Austr.*, p. 737).
See *The Emu*, xliv, 4, April, 1945, p. 321, for notes on the above specimen.

MELITHREPTUS MAGNIROSTRIS North, *Rec. Austr. Mus.*, vi, 1, June 16, 1905, p. 20, pl. 5.
Paratype: O.14271, Eastern Creek, Kangaroo Island, S.A., Oct. 3, 1921.
M. brevirostris, Brown-headed Honeyeater (*R.A.O.U.*, p. 94).
M. atricapillus magnirostris (*Syst. Av. Austr.*, p. 738).

PTILOTIS FRENATA Ramsay, *Proc. Zool. Soc.* (Lond.), pt. 4, April 1, 1875, p. 603.
Types (selected): O.18561, ♂, O.18560, ♀, Cardwell, Queensland, collected May, 1874.
Paratype: O.18562, ♀.
Meliphaga frenata, Bridled Honeyeater (*R.A.O.U.*, p. 99).
M. f. frenata (*Syst. Av. Austr.*, p. 775).

PTILOTIS MACLEAYANA Ramsay, *Proc. Linn. Soc. N.S.W.*, i, 1, April 27, 1875, p. 10.
Types (selected): O.18565, ♂, O.18564, ♀, "Police Camp", Herbert River, near Cardwell, n.e. Queensland, collected April, 1874.
Paratype: O.18563.
Meliphaga macleayana, Macleay Honeyeater (*R.A.O.U.*, p. 99).
Caloptilotis macleayana (*Syst. Av. Austr.*, p. 776).

PTILOTIS KEARTLANDI North, *The Ibis*, (7), i, 3, July, 1895, p. 340.
Type: O.9158, ♂, McMinn's Range, central Australia (Horn Expedition).
Meliphaga keartlandi, Grey-headed Honeyeater (*R.A.O.U.*, p. 100).
Ptilotula k. keartlandi (*Syst. Av. Austr.*, p. 780).
The above specimen figured in *Report Horn Expedition*, pt. 2, Zoology, 1896, pl. 6 (top figure).

PTILOTIS LEILAVALENSIS North, *Rec. Austr. Mus.*, iii, 5, April 17, 1899, p. 106.
Type: O.11167, Leila Vale Station, Fullerton River, Burke District, north Queensland.
Meliphaga penicillata, White-plumed Honeyeater (*R.A.O.U.*, p. 101).
Ptilotula penicillata leilavalensis (*Syst. Av. Austr.*, p. 782).

PHILEMON OCCIDENTALIS Ramsay, *Proc. Linn. Soc. N.S.W.*, (2), ii, 4, March 21, 1888, p. 676.
Type: O.18559, ♂, Derby, n.w. Australia, collected T. H. Bowyer-Bower, 1885.
P. citreogularis, Little Friar-bird (*R.A.O.U.*, p. 105).
Microphilemon citreogularis occidentalis (*Syst. Av. Austr.*, p. 805).

MOTACILLA BARNARDI North, *Proc. Linn. Soc. N.S.W.*, xxx, 4, April 12, 1906, p. 579.
Type: O.14997, Dawson River, Queensland, June 10, 1905.
M. flava, Yellow Wagtail (*R.A.O.U.*, p. 105).
Budytes flava simillima (*Syst. Av. Austr.*, p. 817).

POËPHILA AURANTIIROSTRIS North, *Abst. Proc. Linn. Soc. N.S.W.*, May 28, 1902, p. 4; *Proc. Linn. Soc. N.S.W.*, xxvii, 2, October, 1902, p. 208.
Type: O.12791, ♂, Wyndham, n.w. Australia.
P. acuticauda, Long-tailed Finch (*R.A.O.U.*, p. 108).
P. a. hecki (*Syst. Av. Austr.*, p. 835).

POËPHILA ATROPYGIALIS Diggles, *Trans. Philos. Soc. Queensland*, after August 4, 1876, p. 11.
Paratype: O.23068, ♂, Normanton, Queensland.
P. atropygialis, Black-tailed Finch (*R.A.O.U.*, p. 108).
Alisteranus a. atropygialis (*Syst. Av. Austr.*, p. 837).

In August, 1876, Diggles read a paper before the Queensland Philosophical Society on "Some New and Rare Specimens of Australian Birds". Among the names proposed was *Poephila atropygialis* for a new species of Finch from Normanton, Queensland. Diggles' remarks were published in the *Queenslander* newspaper, 1876 (I have been unable to ascertain the date of issue) and also in the *Transactions of the Queensland Philosophical Society*, presumably later than the newspaper account.

Castelnau and Ramsay in *Proceedings of the Linnean Society of New South Wales*, vol. ii, pt. 4, March, 1877, p. 382, used the name proposed by Diggles, adding "sp. nov.", as they did not consider the newspaper description acceptable scientifically; a footnote to that effect was added. No mention is made by Castelnau and Ramsay of the description appearing in the *Transactions of the Queensland Philosophical Society*, which may not have appeared before March, 1877, although the reference is generally quoted as "1876, after August 3, p. 11". This is the date on which the paper was read before the Society according to an offprint of Diggles' paper (pp. 9-12, titled "Some New and Rare Species of Birds") in the possession of Tom Iredale. In the Annual Report of the Society for 1876 (1877), p. 3, the date is given as August 4, 1876.

The specimen on which Diggles based his description was received by the secretary of the Society from Gulliver. Diggles remarked that Gulliver also sent to the [Queensland] Museum a considerable number of birds of various species. The specimen in the Australian

Museum is marked "type" by Ramsay and also, at a later date, by North. It is a Gulliver specimen from Normanton and was presented by Comte de Castelnau in February, 1877. In view of the above circumstances it is obviously a paratype of the species.

POËPHILA NEGLECTA North, REC. AUSTR. MUS., Vol. v, 4, June 16, 1904, p. 263.
Type: A.99, Queensland ?.
P. atropygialis, Black-tailed Finch (*R.A.O.U.*, p. 108).
Alisteranus atropygialis neglectus (*Syst. Av. Austr.*, p. 837).

POËPHILA ARMITIANA Ramsay, *Proc. Linn. Soc. N.S.W.*, ii, 1, July, 1877, p. 72.
Type: O.18595, ♀, Four Mile Creek, near Georgetown, north Queensland.
P. gouldiae, Gouldian Finch (*R.A.O.U.*, p. 109).
Gouldaeornis gouldiae armitiana (*Syst. Av. Austr.*, p. 836).

AELUROEDUS MACULOSUS Ramsay, *Proc. Zool. Soc.* (Lond.), pt. 4, April 1, 1875, p. 601.
Types (selected): O.18554, ♂, O.18553, ♀, Rockingham Bay, Queensland.
Paratype: O.18552.
Ailuroedus melanotus, Spotted Catbird (*R.A.O.U.*, p. 110).
A. m. maculosus (*Syst. Av. Austr.*, p. 892).

SCENOPOEUS DENTIROSTRIS Ramsay, *Proc. Zool. Soc.* (Lond.), pt. 4, April 1, 1876, p. 591.
Type of the genus and species: O.18551, Bellenden Ker Range, North Queensland, June, 1874.
Scenopoeetes dentirostris, Tooth-billed Bower-bird (*R.A.O.U.*, p. 110).
S. dentirostris (*Syst. Av. Austr.*, p. 889).

CHLAMYDERA ORIENTALIS Gould, *Ann. Mag. Nat. Hist.*, (5), iv, July 1, 1879, p. 74.
Paratypes: O.18556, O.18557, ♂ O.18558, Port Denison, Queensland, collected J. Rainbird, November, 1865.
C. nuchalis, Great Bower-bird (*R.A.O.U.*, p. 111).
Rogersornis n. nuchalis (*Syst. Av. Austr.*, p. 891).

CORVUS BENNETTI North, *Vic. Natur.*, xvii, 9, January, 1901, p. 170.
Types (selected): A.18561, ♂, A.18559, ♀, Moolah, western N.S.W., August, 1883, collected K. H. Bennett.
C. bennetti, Little Crow (*R.A.O.U.*, p. 112).
C. bennetti (*Syst. Av. Austr.*, p. 895).

NOTES ON THE NOMENCLATURE OF *CONULARIA DISTINCTA* FLETCHER AND *CONULARIA TENUISTRIATA* McCOY.

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I am indebted to Dr. Eugene S. Richardson, Jnr., of Bryn Mawr College, Pennsylvania, U.S.A., for bringing to my notice that the species described by me (1938, p. 242) as *Conularia distincta* is preoccupied by *C. distincta* of Boŭcek (1928). I therefore propose a new name, *C. bowningensis*, after the type locality, for the Upper Silurian conularid from Bowning, New South Wales.

It was also pointed out by Dr. Richardson that there is a case of homonymy between *Conularia tenuistriata* McCoy (1847, p. 307) and *C. tenuistriata* Sandberger (1847, p. 15). The question of priority does not arise in this instance, as Sandberger's name is invalid and cannot be adopted. This author redescribed and figured fourteen named species of *Conularia*, at the same time giving them more descriptive names. *Conularia tenuistriata* Sandberger therefore becomes a synonym of *C. gerolsteinensis* d'Archiac et de Verneuil (1842, p. 352), the species he renamed.

The Australian Permian species *Conularia tenuistriata*, named by McCoy, therefore becomes a valid species. An excellent description of this form was published by McCoy, together with three recognizable figures.

References.

Boucek, B., 1928.—Revise Ceskych Palaeozoichyeh Konularii. *Palaeont. Bohemiae*, ii, pp. 1-108.
d'Archiac and de Verneuil, 1842.—*Trans. Geol. Soc. London* (2), vi.
Fletcher, H. O., 1938.—Rec. Austr. Museum, Vol. xx, No. 3.
McCoy, F., 1847.—*Ann. Mag. Nat. Hist.*, Vol. xx, No. 134.
Sandberger, F., 1847.—*Neues Jahrb. für Min. Geol. und Petref.-Kunde.*

NEW LAMELLIBRANCHIA FROM THE UPPER PERMIAN OF WESTERN AUSTRALIA.

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(Plates xxxiv–xxxv.)

Introduction.

In this paper two new genera of lamellibranchia are recognized from the Upper Permian beds of Western Australia. Four species are described from the Wandagee Series, while two are also recorded from the Nooncanbah Series, its northern equivalent in the West Kimberley Division.

The shells are of particular interest as they possess a wide V or chevron-shaped type of ornamentation which is rarely found on palaeozoic shells. They are edentulous, posteriorly-gaping forms, possessing close affinities with mesozoic shells of the Family Pholadomyidae. The two new genera bear a close resemblance to Permian shells recently described from Madagascar by Astre (1934) and also have many points in common with Jurassic shells from the Spiti Shales described by Holdhaus (1913) as *Goniomya* Agassiz and *Cosmomya*, gen. nov.

The specimens with two exceptions were collected by Dr. Curt Teichert, late of the University of Western Australia, at whose request the following paper has been prepared. The material is fairly well preserved but the specimens are in varying stages of incompleteness. The hardness of the matrix in which the shells are preserved prevented any development of internal structures, and the descriptions and conclusions have therefore been based entirely on external characters.

A series of fifteen specimens were collected from the Wandagee Series of the Minilya River district in the North-West Basin. A single specimen (F.38415) was collected by Mr. H. Coley from the same locality, while an incomplete specimen (F.16746) was collected by Dr. H. Basedow in 1914 from Mount Marmion, near Balmaningarra in the West Kimberley Division. The two numbered specimens are in the collection of the Australian Museum, while the remainder are in the collection of the University of Western Australia.

Stratigraphical Position of the Species.

The Wandagee Series immediately underlies the Kennedy Sandstone, which has been placed at the top of the Permian sequence in that area by Teichert (1941, p. 381). Because of the extremely fossiliferous nature of the Wandagee Series, Teichert was able to subdivide it into four stages, each one characterized by a distinct fossil fauna. The stratigraphical positions of the species described in this paper are as follows: In descending order—

Kennedy Sandstone	200 +	feet
Wandagee Series	2,600	„
Linoproductus Stage	1,090	„
Highest fossil horizon.		
Undulomya pleiopleura, sp. nov.		
Lowest fossil horizon.		
Undulomya pleiopleura, sp. nov.		
Palaeocosmomya teicherti, sp. nov.		
Schizodus Stage	340	„
Calceolispongia Stage	560	„
Undulomya rugulata, sp. nov.		
Palaeocosmomya teicherti, sp. nov.		
Lingula Stage	590	„
Palaeocosmomya teicherti, sp. nov.		
P. aplatum, sp. nov.		

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The specimen of *Undulomya rugulata* from the West Kimberley Division was collected from the top beds of the Nooncanbah Series at Mount Marmion, near Balmaningarra. Teichert (1941, p. 389) suggested a correlation between the Wandagee and Nooncanbah Series, so that the occurrence of *Undulomya rugulata* in both horizons is additional evidence in favour of this correlation.

Discussion of Genera.

The two new genera from Western Australia bear a close resemblance to Jurassic bivalves and there seems to be little doubt that it is to Mesozoic forms such as *Goniomya*, *Pholadomya* and *Cosmomya* that we must look for close comparisons. Holdhaus (1913, p. 450) described and figured *Goniomya uhligi* and (1913, p. 446) *Cosmomya egregia* from a Jurassic fauna of the Spiti Shales. These species, based on incomplete specimens, possess a striking resemblance to the Australian genera *Undulomya* and *Palaeocosmomya* respectively. The genus *Cosmomya* is unknown outside the Spiti Shales, but *Goniomya* is a well-known genus with a wide distribution.

It has usually been accepted that the genus *Goniomya* did not occur in strata older than the Jurassic, although, as far back as 1885, Krotov (1885) recorded a shell from the Artinskian of Russia as *Goniomya artiensis*, while Geinitz (1880, p. 38) described a species with the typical ornamentation of *Goniomya* as *Pholadomya kasanensis*.

These two species were accepted by Netschajeff (1894) as belonging to the genus *Goniomya*, presumably more on the evidence of the V-shaped ornamentation than other characters. He pointed out features of difference from the typical mesozoic species of *Goniomya* in the position of the umbones, the degree of inequilaterality and the broadness of the posterior margin. Diener (1903, p. 176) agreed with Netschajeff that these differences were insufficient to remove the Russian species from the genus *Goniomya*, as he pointed out that there is a great deal of variation in its species. Diener thought, however, that the generic determination of the two Russian species was not entirely free from objection. At the same time he recorded and figured an incomplete shell from the Kuling Shales of Kuling in Spiti (Permian) as *Goniomya* sp. indet. aff. *G. kasanensis* Geinitz. Diener (1903, p. 126) also described a further incomplete shell as *Goniomya* sp. indet. from the Productus Shales at Kalapani in Byans (Permian). In recording this species Diener states that "it seems rather hazardous to quote this genus in a permian fauna . . . it would however, be very difficult to decide in which genus the shell here under consideration ought to be placed, as in all its external characters it resembles so closely a Jurassic *Goniomya*".

Within recent years other references in literature have appeared regarding the occurrence of *Goniomya* in rocks of Permian age. Dighton Thomas (1928, pp. 224–229) described and figured three species of shells with a type of V-shaped ornamentation from a fauna recorded as "Upper Carboniferous from the Omatpe Mountains of North-Western Peru". The shells were referred to the genus *Sanguinolites* in preference to *Goniomya*. Thomas states that interruption of the ribbing is not at all a common feature of the lamellibranchia, though it is a typical character of *Goniomya*. He compared one species, *S. inordinatus*, with *S. v-scriptus* of Hind (1900, p. 382), stating that it is quite different from the Permian *Goniomya* of Russia and the Himalayas. Thomas refers his other two species, *S. insolitus* and *S. deportatus*, to the genus *Sanguinolites* as they appear to belong to that genus, although, as he states, the ornamentation is not normal for it.

From the Permian beds of Madagascar, Astre (1934, p. 82) has described two species of shells with typical V-shaped ornamentation as *Goniomya* sp. aff. *kasanensis* Geinitz and a new species *G. disangula*. These two species in my opinion are very similar to the shells from Western Australia and should be included in the two genera described in this paper as *Undulomya* and *Palaeocosmomya* respectively.

In a recent paper Vangerow (1937) lists the Mesozoic species of *Goniomya* and includes Diener's Himalayan forms in one of the Jurassic species. He mentions, however, that the Permian species may belong to another genus but gives no reasons.

Shells with a characteristic V-shaped ornamentation, usually considered to be typical of the genus *Goniomya*, have therefore been found and recorded from upper palaeozoic rocks in Russia, Peru, Madagascar, Australia, and the Central Himalayas. With the exception of the shells from Peru, authors have referred them to the genus *Goniomya*, but usually with some degree of doubt or hesitancy. Before it can be accepted that the vertical range of *Goniomya* must be considerably extended to embrace a number of Permian species, it is necessary to establish exactly the generic characters of that genus. The interrupted type of ribbing, or V-shaped ornamentation, has been stressed as an important character of *Goniomya*. It is a form of sculpture not usually found in the lamellibranchia, but it certainly cannot be considered as a distinctive generic character.

The genus *Goniomya* was instituted by Agassiz (1842, p. 1) to include Jurassic shells with a characteristic type of V-shaped ornamentation and gaping extremities.

A great deal of variation is apparent in the thirty-three species which Agassiz referred to his genus *Goniomya*. The shell characters show such diversity of form that Agassiz was able to subdivide the genus into groups which he referred to as Ovale, Tronquées, Cylindracées and Trapèzoides. For a restricted diagnosis of the generic characters of *Goniomya* it is necessary to refer to the type species of the genus. Agassiz did not designate a genotype, so the type of the genus automatically becomes *Goniomya sulcata*, the first species described. It is a distinctive form belonging to the Cylindracées group and is well figured by Agassiz (1842, Pl. 1, figs. 8–9; Pl. 1*b*, figs. 9–12; Pl. 1*c*, figs. 13–14). The specimens appearing first in the illustrations (Pl. 1*b*, figs. 9–12) are excellent reproductions and are the nearest in appearance to the Australian Permian shells.

The description of *G. sulcata* is briefly as follows:

General form of the shell elongate and cylindrical; anterior margin short, truncated, and not the depth of the shell. Slightly gaping anteriorly. Posterior portion of shell strongly developed and not attenuated at the posterior margin, rather with a tendency to broaden and widely gaping; obliquely truncate.

Ribs strong, rounded and V-shaped, separated by moderately large intervals. Anterior ribs deeper and more pronounced, less numerous than posteriorly, directed obliquely behind so that the last run more or less parallel with the top edge. Ribs over-run with fine striations. Beaks little elevated and contiguous. A long and well-marked escutcheon, deep near the umbones, shallowing posteriorly, is present. A lunule is also developed.

Conclusions.

The Western Australian shells described in this paper as *Undulomya* appear to have some affinities with the Jurassic genus *Goniomya* (*sensu lato*). They are very similar to, if not identical with, the shell described from Madagascar as *Goniomya* sp. aff. *kasanensis* Geinitz, and therefore possess relationships with similar Permian shells from the Himalayas and Russia. Their relationships with the Peruvian species are more obscure, although *Sanguinolites insolitus* of Thomas has a number of characters in common with the Australian forms of *Undulomya*.

There are a number of important features found in the Permian genus *Undulomya* which clearly distinguish it from the mesozoic genus *Goniomya*, and these are discussed later in this paper. The long geological break between these two genera is also an important factor and at least indicates a likely dissimilarity in morphological structures. It was found necessary, therefore, to institute a new genus for the Western Australian shells after the form of *Goniomya*, as they could not be satisfactorily placed in that genus.

The relationships of the new genus *Palaeocosmomya* and its points of difference from the Jurassic genus *Cosmomya* of Holdhaus are detailed later in this paper.

Systematic Descriptions.

Phylum MOLLUSCA.
Class LAMELLIBRANCHIATA.
Order *Anomalodesmacea.*
Superfamily *Pandoracea.*
Family *Pholadomyidae.*

Genus Undulomya gen. nov.*

Genotype: *Undulomya pleiopleura* sp. nov.

Generic Characters.—Shell elongate, equivalve, very inequilateral, moderately convex becoming compressed posteriorly and inferiorly. Anterior portion very short and vertically narrowed; margin rounded inferiorly. Posterior portion produced, with a bluntly-pointed posterior margin. Umbones situated anteriorly, close to anterior margin, depressed, not prominent, directed and sloping anteriorly. Escutcheon long and triangular, flattened, extending to the posterior margin; an oblique posterior-directed ridge separates it into two unornamented areas. Lunule small. Shell gaping posteriorly, no anterior gape. Edentulous.

Interior musculature characters unknown.

Ornamentation consists of anterior V-shaped ribs with heavy curved ribs and wide interspaces posteriorly. Line of inflection of V-shaped ribs extends backwards and downwards at approximately an angle of 35°. A narrow inferior margin on which ribs do not extend, tapering and finally disappearing half-way along the shell. Valves covered with fine concentric lines of growth.

Shells approximately 80 to 90 mm. in length and from 40 to 45 mm. in height.

Observations.—Nine specimens in varying degrees of completeness are referred to this genus and represent two distinct species. Its nearest relationships are with the mesozoic genus *Goniomya* and with almost identical Permian shells from Madagascar and the Himalayas which have been referred by authors to that genus. The genus *Undulomya* differs from *Goniomya* in the following features: The general outline and appearance are dissimilar in that the posterior extremity becomes somewhat attenuated by a persistent curving of the inferior margin and consequent decrease in depth. The umbones are very depressed, directed anteriorly and situated near the anterior extremity. The position of the depressed umbones on the anterior slopes gives the shell a rather characteristic twisted or leaning appearance in that direction.

A well-developed escutcheon is present in the genus *Undulomya.* It is bordered superiorly by a straight hinge-line and inferiorly by a definite ridge or fold. Between this fold and the ornamented, convex part of the valve is a distinct elongated groove which is free from ribbing. A distinct lunule is absent.

These rather characteristic features, together with the fact that there is no anterior gape and the posterior gape of the shells is not nearly as pronounced as in the genus *Goniomya,* are of sufficient generic importance to justify the erection of a new palaeozoic genus. Furthermore, the ribbing on shells of *Undulomya* appears to be of a heavier type and far more pronounced than is found in the genus *Goniomya,* although the ornamentation follows the same pattern.

The shell described by Astre (1934, p. 82, Pl. x, figs. 12–14) as *Goniomya* sp. aff. *kasanensis* Geinitz, in my opinion, must be included in the genus *Undulomya.* It is very similar in every respect, and the specimen (1934, Pl. x, fig. 14) shows clearly the escutcheon, the oblique ridge, and the twisted appearance of the valves. The line of inflection of the V-shaped ribs passes backwards and downwards at the same angle as in specimens of *Undulomya.* The specimen figured by Diener (1903, Pl. viii, fig. 11) as *Goniomya* sp. ind. (aff. "*kasanensis*" Geinitz) differs from the Western Australian and Madagascan shells in that the line of inflection of the V-shaped ribs is vertical and the umbo is not twisted and directed anteriorly. On the other hand there is a slight indication of the escutcheon which is so well developed in the genus *Undulomya.* Owing

* Ety.: *unda,* a wave, from the wavy appearance of the valves; *Mya,* a genus of shells.

to the fragmentary nature of the Himalayan shells it was impossible to give any dimensions, but as far as the Madagascan shell is concerned, its size agrees well with *Undulomya pleiopleura* from Western Australia.

It is possible that the shells from north-west Peru, mentioned earlier in this paper, may have some relationships with the genus *Undulomya*. Three species with characteristic ornamentation were described by Dighton Thomas (1928, pp. 224–229), and of these, *Sanguinolites insolitus* has many features in common with the Australian Permian genus.

The known geological range of the genus *Undulomya* in the Western Australian Permian deposits is the Wandagee Stage of the North-West Basin and its northern equivalent, the Nooncanbah Stage of the West Kimberley Division.

Undulomya pleiopleura sp. nov.

(Plate xxxiv, figs. 1–5; plate xxxv, fig. 1.)

Holotype: WF10.1 (A). *Paratypes*: WF10.1 (B); T5 (A). Collection of the University of Western Australia.

Specific Characters.—Shell equivalve, very inequilateral, elongated becoming somewhat attenuated posteriorly. Moderately convex with maximum inflation in the dorsal mid-line, declining rapidly anteriorly and inferiorly but gradually posteriorly. Anterior portion about one-sixth the entire length of shell; its margin straight to concave above, bluntly rounded and projecting below. Ventral margin long, slightly curved anteriorly, then almost straight until near the posterior extremity it rapidly curves upwards to meet the rather truncated posterior margin of the flattened dorsal area. Hinge-line straight, inclining posteriorly.

The umbones are low, depressed, inclined and directed anteriorly, giving the valve a somewhat leaning and twisted appearance in that direction. The points of the umbones are contiguous, recurved slightly and overhanging the hinge-line. A pseudo-lunule is present. The escutcheon is long and narrow, extending from below the umbo to the posterior border, and gradually widening. It is bordered superiorly by the straight hinge-line and inferiorly by a prominent fold or ridge originating below the umbo and extending obliquely backwards to the posterior margin. It is separated from the swollen and ornamented valve flanks by a well-defined groove which increases in width posteriorly. The escutcheon and groove are flat or slightly concave and unornamented, with the exception of very fine, curved growth striae which cross from the hinge-line on to the ornamented part of the valve. The median ridge or fold is ornamented with short ridges, their line of direction being opposite to that of the valve ribbing, except on the posterior half, where it is the same. (See Pl. xxxiv, fig. 2.) A well-pronounced ligamental area, of which only a portion is preserved on one specimen, indicates a well-developed external ligament of an amphidetic type.

The ornamentation consists of prominent rounded ribs, V-shaped anteriorly, curved posteriorly, and gradually increasing in size until, on the posterior third of the valve, they are large with wide interspaces. The larger and curved ribs are independent and do not form an arm of the anteriorly-placed chevrons.

The line of inflection of the V-shaped ribs originates at the apex of the umbo and extends backwards and downwards at an angle of about 45° but does not reach the inferior border. Around this border is a narrow margin, tapering posteriorly, ornamented with crowded, fine striae and on which the main valve ribbing does not extend. (See Pl. xxxiv, figs. 5–6.)

The ribs anterior to the line of inflection are eleven in number, crowded near the umbo and becoming stronger, with wide and deep interspaces towards the ventral margin. They originate from below the umbo and are more or less concentric, following the course of the growth striae.

The ribs posterior of the line of inflection extend obliquely upwards and backwards and, when crossing the post-umbonal swelling, curve sharply forwards and terminate

on the edge of the elongated groove or furrow. Traces of the ribbing are then visible on the ridge bordering the escutcheon, but directed sharply backwards, and are more in the form of nodules. These ribs, forming the posterior arms of the V-shaped ornamentation, are about fourteen in number. The remaining independent posterior ribs are about ten in number, originating from the ventral border and passing well backward before curving upward over the valve and adopting a greater curvature on the swelling of the valve near the superior margin. Traces of these ribs appear on the post-umbonal ridge and follow the course of the ribs, the exact opposite to what is found on the ridge near the umbo.

Although not well preserved, there are indications that the valve was covered with numerous, fine and closely arranged concentric striae of growth.

Internal structures are not visible on any specimens, but there is no doubt the shells are edentulous.

The dimensions of three specimens are as follows:

	Holotype.		Paratype.
	WF10.1 (A).	WF5.12 (A).	T5 (A).
Length	98 mm.	74 mm.*	62 mm.*
Height	38 mm.	34 mm.	34 mm.
Width	30 mm.	28 mm.	28 mm.

Observations.—The species of the genus *Undulomya* are quite unlike any other lamellibranchs found in the Permian rocks of Australia. As pointed out earlier in this paper, the shell from Madagascar, described as *Goniomya* sp. aff. *kasanensis* by Astre, is very similar and must be included in the genus *Undulomya*. It appears to have fewer ribs, but other points of similarity are most striking. The dimensions, as far as can be determined from the measurements of the incomplete specimens, agree very well with those of the Australian shells.

Sanguinolites insolitus described by Dighton Thomas from north-west Peru, although a much smaller shell, has some important characters in common with *Undulomya pleiopleura*. The already-mentioned Himalayan species differs from this species in the umbones being erect and in the vertical line of inflection of the anterior V-shaped ribbing.

The specimen figured on Plate xxxiv, figures 3–4, differs slightly from the typical specimens in that the ribs are more pronounced with deeply-excavated interspaces.

Localities and Geological Horizons.—Western Australia: Uppermost beds in centre of syncline, one mile west of Coolkilya Pool, north bank of Minilya River, Wandagee Station, North-West Basin. Holotype and paratype locality; west limb of syncline, Coolkilya Flat, north of Wandagee Hill, Wandagee Station. (Lowest fossil horizon, Linoproductus Stage, Wandagee Series.) Three hundred yards east of south-eastern gully of Wandagee Hill, Mungadan Paddock, Wandagee Station. (Highest horizon, Linoproductus Stage, Wandagee Series.)

Undulomya rugulata sp. nov.

(Plate xxxiv, fig. 6; plate xxxv, figs. 2–3.)

Holotype: WC(27–32)1 (A), collection of University of Western Australia.

Specific Characters.—Shell equivalve, very inequilateral, convex, maximum inflation in the mid-line and nearer the posterior than the anterior extremity. Anterior portion of shell short with rounded margin. Ventral margin sloping from anterior and posterior margins so that the greatest height of the shell is in the central position. Umbones depressed, situated low on the anterior slope, directed anteriorly and slightly twisted; apices contiguous and overhanging the hinge-line.

Ornamentation consists of about fifteen sharply keeled, concentric, anterior ribs, and about twenty-seven upwardly directed, rounded, posterior ribs. These are crowded on the umbonal region but become widely spaced towards the inferior and the posterior

* Incomplete. Measurement given is actual length of incomplete shell.

margins. From the apex of the umbo there extends backwards and downwards at an angle of approximately 45° a distinct groove which does not quite reach the ventral margin. At this groove the concentric ribs bend sharply upwards and posteriorly with only a slight curve, until, when crossing the dorsal slope and nearing their extremities, they bend sharply forwards. The most inferiorly placed concentric rib does not bend upwards but continues around the shell as a distinct concentric rib. Below this rib the valve surface is smooth and unornamented, with the exception of well-defined and crowded concentric lines of growth. Approximately twelve of the most posteriorly placed ribs do not junction with the anterior concentric ribs and thus do not form the wide V-shaped ornamentation found on the anterior half of the valve. They follow the same general course, but their lower extremities end slightly above the main concentric rib. The upwardly-directed posterior ribs are rounded with wide interspaces and are not nearly as sharp or keeled as the anterior concentric ribs.

The surface of the valves is covered with numerous fine striae of growth.

Internal characters not exhibited.

The dimensions of the holotype are:

Length	73 mm.[1]	85 mm.[2]
Height	40 mm.	42 mm.
Width	30 mm.	30 mm.

Observations.—This unmistakable species is represented by two incomplete specimens from two localities. The holotype is in a fairly good state of preservation, but unfortunately the whole of the superior flattened portion including the escutcheon and the posterior extremity is missing. It differs markedly from *Undulomya pleiopleura* in that the independent posterior ribs, those not forming the V-shaped ornamentation, are far more vertical and do not assume the great width of the posterior ribbing in *U. pleiopleura*. The height in relation to length is greater in this species; as in the former species the shell is very strongly produced posteriorly.

Localities and Geological Horizons.—East limb of syncline, north bank of Minilya River, Wandagee Station, North-West Basin. Holotype locality. (Lower 100 feet in the Calceolispongia Stage, Wandagee Series.) Mount Marmion, near Balmaningarra, West Kimberley Division. (Nooncanbah Stage.)

Genus Palaeocosmomya gen. nov.*

Genotype: *Palaeocosmomya teicherti* sp. nov.

Generic Characters.—Shells equivalve, inequilateral, about one and a half times as long as high, moderately inflated, widely gaping posteriorly. Anterior margin rounded, merging evenly into a downwardly inclined and but slightly curved ventral margin; posterior margin rounded, projecting inferiorly. Hinge-line short, straight, depressed. Lunule small, escutcheon distinct and widely triangular. Ligamental area or depression beneath and posterior to umbones.

Umbones conspicuous, inflated, apices twisted anteriorly. A narrow, well-defined groove traverses the valve from the apex of the umbo to the ventral margin with a slight forward incline.

Ornamentation consists of concentric ribs on the anterior half of the valve and an almost vertically arranged line of V-shaped ribs with short anterior and elongated posterior arms on the posterior half of the shell. The umbonal groove traverses the concentric ribs and is not a line of inflection.

The shells range to a length of 45 mm. and a height of 30 mm.

Observations.—A series of six incomplete specimens has been referred to this genus and includes two species. These shells possess many characters which link them with the Jurassic genus *Cosmomya* of Holdhaus (1913, p. 46). This genus was described

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[1] Actual incomplete dimensions.

[2] Approximate complete dimensions.

* Ety.: *palaios*, ancient; *Cosmomya*, a genus of shells.

from a single cast of a left valve which unfortunately is an incomplete specimen with no complete margins. The Australian Permian shells possess a variation in the pattern of the ornamentation but in most of the other exhibited characters appear to be very similar. It is most improbable that shells with such a highly specialized type of ornamentation would persist through a long geological range, and I am confident that when complete shells of *Cosmomya* can be compared with the Australian Permian shells there will be little difficulty in determining them as being distinct forms.

I can find very few points of dissimilarity between *Goniomya disangula* of Astre (1934, p. 83) and *Palaeocosmomya teicherti* sp. nov. The specimens are remarkably alike and there is little doubt that his species must be referred to the Australian genus *Palaeocosmomya.* Holdhaus (1913, p. 46) indicates a relationship of *Cosmomya* with *Ceromya* because of the general shape, position of the umbones and their inwardly curved nature, and the ornamentation. Astre saw a relationship with certain "*Anatina*" of the Secondary because of the umbo possessing a transverse groove or fissure, but apart from this feature they have little in common. In *Palaeocosmomya* the sloping sides of the cardinal area indicate a well-developed parivincular type of ligament. It is impossible, however, to come to any definite conclusions from the incomplete material in which internal structures are entirely lacking, and so for the time being the genus is placed in the Family Pholadomyidae.

The genus *Palaeocosmomya* is so far known only from the Wandagee Series of the North-West Basin.

Palaeocosmomya teicherti sp. nov.

(Plate xxxiv, figs. 7–8; plate xxxv, figs. 4–6.)

Holotype: WC(27–32)1A, Paratype T171A, collection of University of Western Australia.

Specific Characters.—Shell equivalve, inequilateral, sub-ovate, evenly convex, one and a half times as long as high. Anterior margin rounded, merging with a downwardly inclined but slightly convex ventral margin. Posterior margin rounded with a tendency for the shell to thicken, in the form of a lip along the border. Hinge-line straight, short and depressed below superior border. Posterior extremity of shell widely gaping.

Umbones conspicuous, elevated, apices overhanging hinge-line, contiguous and recurved slightly anteriorly; situated slightly anterior of a vertical median line. A narrow well-defined groove, originating at the apex of the umbo, passes down the valve to the ventral margin with a slight forward inclination.

The ornamentation consists of comparatively heavy, more or less concentrically arranged ribs on the anterior half of the valve which become V-shaped posteriorly. The anterior ribs are about 18 to 20 in number and become more widely separated as they approach the inferior margin. They originate at the anterior margin and pass more or less concentrically backwards, but with an upward tendency, to a line of inflection which is vertical between the centre of the umbo and the inferior margin. Shortly after crossing the anteriorly inclined narrow groove, where the upward tendency of the ribs is more pronounced, they bend abruptly downwards at an angle of about 45° to a main line of inflection forming the base of the Vs. This line extends from the point of the umbo to the inferior margin at an angle of about 30°. At this line of inflection the ribs bend sharply upwards and backwards to a well-defined ridge separating the ornamented convex portion of the shell from the escutcheon.

Lunule short and broad. Escutcheon well defined, broadly triangular, extending to the posterior margin. It is bordered inferiorly by a distinct ridge or fold which originates from behind the apex of the umbo and passes backwards and downwards to meet the posterior margin at a little above its central position. Superiorly it is bordered by a short, straight hinge-line for half the distance, the margin then rising slightly and curving outwards and downwards to form the beginning of the gape and the upper part of the posterior margin. The actual posterior border is bent outwards to form a definite lip. The surface of the escutcheon is convex and is unornamented.

Also originating from behind the umbo is a narrow ridge which very soon merges into the convex surface of the escutcheon (see Pl. xxxv, fig. 5). Between it and the depressed hinge-line is a narrow, elongated, downwardly-sloping area, deep in the umbonal region and gradually flattening posteriorly to disappear at the same time as the small median ridge. This area was for the reception of the ligament. It is not continued forward of the umbo and would appear to be of the parivincular type.

The dimensions of several specimens are as follows:

	WC(27–32)1B (Holotype).	T.171A (Paratype).
Length	33 mm.*	33 mm.
Height	27 mm.	23 mm.*
Width (both valves) ..	20 mm.	20 mm.

Observations.—Five specimens have been referred to this species and of them two only are in any way complete. The holotype consists of both valves with only the ventral margin missing, but the ornamentation is not well preserved. The specimen selected as paratype is a left valve which has the sculpturing well preserved but with all the margins missing with the exception of a small portion of the hinge-line.

The shells of this species are outstanding on account of the characteristic ornamentation, the broad unornamented escutcheon and the widely-gaping posterior margins with thickened edges. The ornamentation agrees with a species described by Astre (1934, p. 83) from Madagascar, but other characters of the shell agree more perfectly with *Palaeocosmomya aplatum*, another Western Australian species described in this paper.

The present species bears a remarkable resemblance to a Jurassic form described by Holdhaus (1913, p. 446) from the Spiti Shales but differing in that the V-shaped ribbing on the posterior half of the valve is not well defined in comparison with the Australian shells. The escutcheon is also not as well developed or as broad posteriorly. It is unfortunate that the material is incomplete, otherwise more definite conclusions could be made.

Localities and Geological Horizons.—East limb of syncline one mile west of Coolkilya Pool, north bank of Minilya River, Wandagee Station. (Holotype locality); near mouth of north-western gully of Wandagee Hill, Wandagee Station. (Paratype locality). (Linoproductus Stage, Wandagee Series.) On road from Wandagee Homestead to Garden outcamp, Wandagee Station (Lingula Stage, Wandagee Series).

Palaeocosmomya aplatum sp. nov.
(Plate xxxv, figs. 7, 8.)

Monotype: WL1(A). Collection of University of Western Australia.

Specific Characters.—Shell equivalve, inequilateral, moderately inflated anteriorly, compressed posteriorly. Anterior margin projecting with little depth, rounded inferiorly; anterior half of the ventral margin straight, inclining downwards and becoming curved posteriorly to form a rounded and projecting postero-ventral margin. The posterior margin is slightly concave superiorly. Postero-dorsal margin rounded, passing forward and inward to join the short, straight hinge-line. Shell gaping fairly widely with a dorsal maximum width.

Umbones prominent, elevated, much higher than the hinge-line, situated anteriorly. Escutcheon broadly triangular. Ligamental area posterior to the umbones, deep near them but shallowing posteriorly and disappearing before the end of the hinge-line. A narrow, well-defined groove extends from the apex of the umbo to the ventral margin; on the umbonal slope it is vertical but gradually inclines forwards for the lower half of its length.

Ornamentation consists of fairly heavy sub-concentric anterior ribs and finer V-shaped ribs on the posterior half of the valves. The anterior ribs originate at the anterior margin with a slight downward slope before bending upwards at a slight angle

* Incomplete. Actual incomplete dimensions.

and passing round the valve to a line of inflection slightly posterior to the umbonal groove. At this point the ribs lose some of their thickness and bend abruptly downwards to a second line of inflection which forms the bases of the V-shaped ribs. The ribs then pass sharply backwards and upwards to the edge of the broad escutcheon. The extreme compressed posterior portion of the shell does not possess ribbing.

The dimensions of the monotype are as follows:

Length	46 mm.
Height	25 mm.*
Width (both valves)	17 mm.
Hinge-line	24 mm.

Observations.—This species differs from *Palaeocosmomya teicherti* in being strongly compressed posteriorly and inferiorly and as a result the posterior gape is not as wide. The umbones are also situated more anteriorly. The single specimem belonging to this species has the umbones broken off while a small portion of the ventral margin is also missing. This shell is very similar to the species described and figured by Astre (1934, p. 83, Pl. x, figs. 15, 17) but differs in being more compressed. The umbones are more elevated in the Australian shell and the height in relation to length is greater.

Locality and Geological Horizon.—East limb of syncline, north bank of Minilya River, near Coolkilya Pool, Wandagee Station. (Lingula Stage, Wandagee Series.)

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EXPLANATION OF PLATES XXXIV-XXXV.

Plate xxxiv.

Undulomya pleiopleura sp. nov.

Fig. 1.—Left valve showing broad posterior ribs and oblique post-umbonal ridge. Anterior portion with ribs and line of inflection and part of ventral margin missing. No. WF10.1.

Fig. 2.—Incomplete left valve exhibiting ornamentation on the oblique post-umbonal ridge. No. WF10.1B. (Paratype.)

Fig. 3.—Right valve with exceptionally heavy posterior ribbing. No. T5 (A). (Paratype.)

Fig. 4.—Left valve with well-defined ribbing and line of inflection. Flattened dorsal area and posterior extremity of shell are missing. No. T5 (A).

Fig. 5.—Impression of portion of the ornamentation at the line of inflection and also showing the ventral margin area on which the V-shaped ribs do not extend. No. WF10.4.

Undulomya rugulata sp. nov.

Fig. 6.—Portion of right valve with finely keeled anterior ribs, line of inflection and rounded posterior ribs. Also exhibited is the single concentric rib which traverses the smooth ventral marginal area. No. F 16746.

Palaeocosmomya teicherti sp. nov.

Fig. 7.—Left valve of holotype with ventral margin missing. Dorso-ventral umbonal groove is exhibited. No. WC(27-32)1A.

Fig. 8.—Dorsal view of the holotype showing short hinge-line and extent of posterior gape.

Plate xxxv.

Undulomya pleiopleura sp. nov.

Fig. 1.—Right valve of the holotype, complete ornamentation and upward curve of the ventral margin nearing the posterior extremity. No. WF10.1A.

* Height incomplete. Actual measurement of shell.

Undulomya rugulata sp. nov.

Fig. 2.—Left valve of holotype, posterior extremity missing, exhibiting ornamentation and smooth ventral marginal area with single concentric rib. No. WC(27-32)1A.

Fig. 3.—Anterior view of the holotype.

Palaeocosmomya teicherti sp. nov.

Fig. 4.—Left valve of paratype with the broadly triangular escutcheon not preserved. No. T171.

Fig. 5.—Incomplete right valve of an immature shell showing the dorsal area.

Fig. 6.—Right valve of the holotype with complete posterior margin. The ventral margin and ornamentation are not preserved.

Palaeocosmomya aplatum sp. nov.

Fig. 7.—Right valve of the monotype. The umbones and a small portion of the ventral margin, posterior of the mid-line, are missing. No. WL1.

Fig. 8.—Dorsal view of the monotype showing compressed posterior portion of the shell. The curvature of the posterior margin, forming the gape, is shown by the left valve.

G. C. Clutton, photo.

DIAGNOSES OF NEW RATS FROM THE NEW GUINEA AREA.

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Since inception of the Department of Mammals in 1919, attention has been given to obtaining collections from New Guinea and the South-West Pacific, for which the Museum was mainly dependent upon the voluntary activities of residents and administrative officers. Appreciative acknowledgement is made for the following collections, which included rat species of importance regarding the scrub typhus problem in war time:

From the Mount Lamington District, inland from Dobodura, Northern Division of Papua, from 1927–1929, representative mammal collections[1] were received from Mr. C. T. McNamara, Resident Magistrate. From the Buin district of Bougainville Island collections were obtained from the Rev. Father J. B. Poncelet, S.M., of especial interest for the discovery of a giant rat, *Unicomys ponceleti*,[2] which Rummler and Ellerman have since wrongly relegated to the genus *Melomys*. Included also was an insular race of *Rattus praetor*,[3] first described from Guadalcanal by Thomas, and mistakenly recorded from New Guinea by Tate. From 1936–1939 interesting series of mammals were received for identification from Dr. C. E. M. Gunther, Medical Officer of the Bulolo Gold Dredging Company, as potential "animal reservoirs" of scrub typhus in the Wau-Bulolo area.

As stated in a paper, "Diagnoses of New Mammals from the South-West Pacific",[4] several collections relevant to war-time investigations of scrub typhus were submitted for identification by A.I.F. and U.S. research units. The major collection, submitted during 1944 by Colonel Cornelius B. Philip and Major Glen M. Kohls, on behalf of the U.S. of America Typhus Commission, covered not less than six consignments totalling about 600 specimens. Resulting from work on these collections, field-work was carried out by the author in the New Guinea area,[5] as recommended by Colonel Philip. Following on the period of service with the Tropical Scientific Section, A.I.F., under direction of the Commonwealth Scientific Liaison Bureau, it was hoped to prepare a comprehensive review of the relevant mammal species.

Unfortunately, various difficulties and additional duties have militated against completion of the work. In the present paper, therefore, it seems advisable to provide preliminary diagnoses of various new forms of *Rattus*, with a brief résumé of their complicated group affinities.

Most of the present confusion has resulted from disregard by authors of the basic characters used by Oldfield Thomas for the definition of species and genera, especially in the hastily prepared, inconclusive, and often misleading work of Rummler.[6] For example, disregard for the importance of the mammary formula concerning group affinities within the *Rattus* genus, must have contributed to his error in transferring the stout-skulled and broad-footed *Rattus mordax* of N.E. Papua, together with the much larger Vogelkop species *coenorum* and *bandiculus* (2–2=8 mammae), to the genus *Stenomys* (1–2=6) which Thomas diagnosed as having slender feet, and a smooth "scarcely ridged" skull with a long narrow muzzle.

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[1] Troughton.—Rec. Aust. Mus., xx, 2, 1937, pp. 117-127.

[2] Troughton.—Rec. Aust. Mus., xix, 4, 1935, pp. 259-262, pl. xix.

[3] Troughton.—Rec. Aust. Mus., xix, 5, 1936, pp. 341-353.

[4] Troughton.—Rec. Aust. Mus., xxi, 6, 1945, pp. 373-5.

[5] Troughton.—Review of Field Investigations concerning the Mammal Reservoirs of Scrub Typhus—*Commonwealth (Restricted) Report, Trop. Sci. Sect.*, 2, 1945.

[6] Rummler.—Die Systematik und Verbreitung der Muriden Neuguineas. *Mitt. Zool. Mus. Berlin*. 1938, Vol. 23, 1, pp. 1-297, pls. i-ix.

Specific Distinction of Rattus ringens and mordax.

Fortunately, Ellerman[7] rejected Rummler's incorrect use of *Stenomys*, but did subscribe to the sinking of *R. mordax*, and its more or less allied forms, with *R. ringens*, as mere races of *R. leucopus* of Cape York. Thus, an impossible range, to the Vogelkop of Dutch New Guinea, has been accorded to a preposterous super-species, compounded of several forms diagnosed as specifically distinct by Thomas. Inconsistently, Rummler and Ellerman resuscitated *ratticolor*, which Thomas[8] had relegated to the synonymy of *ringens*, which he regarded as evidently the common *Rattus* in the Snow Mountains country, south of the Nassau Range in Dutch New Guinea.

Regarding the affinities of *R. leucopus*, comparison of a topotypical young female in the "old collection" of the Australian Museum, with two topotypes of *ringens*, kindly provided by Dr. G. H. H. Tate from the Archbold Collections in the American Museum of Natural History, exhibit characters which support the obvious geographical separation of the species. The skull of the female *leucopus*, with unworn molars, has a relatively much wider cranium, as emphasized by the much greater width posteriorly of the zygomatic arches. The interorbital is narrower, and more evenly curved owing to lack of the strong flattened ridging, the angling of which gives the somewhat *norvegicus*-like appearance to the crania of true *ringens*. The incisive foramina are decidedly smaller, and molar row relatively larger, in the young female *leucopus*. The tail is relatively much longer, being 14 mm. longer than the head and body, as opposed to 16–38 mm. shorter in the New Guinea series of *ringens*.

Apparently, the complex and inconclusive treatment of the *ringens-mordax* "group" by Tate[9] was due to an impression that the type locality of *mordax* was in the Port Moresby district. Actually, the collection of C. A. W. Monckton listed by Thomas[10] came from an area northward of Cape, not "Port", Nelson, as then stated. The type locality, recorded by Thomas as "at about 8° 30′ S. lat., 148° E. long.", is across the Owen Stanley divide from Port Moresby, in the Northern Division of Papua. Evidently the locality was in or adjacent to the Buna-Dobodura area, thus making the Mt. Lamington and Dobodura series of *mordax* reasonably topotypical. Comparison of these series with the topotypes of *ringens*, and the U.S.A.T.C. series from Dobodura, provides diagnostic characters which definitely distinguish the species. Some of the differences, confirmed in consultation with Dr. David H. Johnson, Associate Curator of Mammals, U.S. National Museum, during his service with a U.S. Naval Research Unit in the S.W. Pacific, are listed below.

A. Tail longer, brown, mostly variegated yellowish-white towards end; scales raised, usually longer than broad. Pes narrower, hairs whitish. Skull lighter and narrower; incisive foramina much wider, evenly curved outward. Mammae 1-2=6 ..... *ringens*

AA. Tail shorter, unicoloured blackish; scales more smoothly adpressed and broader than long. Pes broader, hairs blackish-brown. Skull stouter and broader; incisive foramina decidedly narrower, not evenly curved outward. Mammae 2-2=8 ..... *mordax*

Arising from the above summary, and comparison of material, the Dobodura series referable to *R. ringens* is diagnosed as a geographical race.

Rattus ringens dobodurae subsp. nov.

Diagnosis.—A more robust and duller mid-brown form than the typical race of the Fly River delta. Dorsal coloration about sepia-brown, compared with the brighter tawny-olive tone of typical *ringens*; sides paler, less ochraceous, washed with vinaceous to cinnamon buff (Ridgway). Entire belly pale to whitish olive-buff, the Dobodura series lacking the bright cinnamon to tawny chest-patch of the typical race. The tail is relatively longer, and the pes larger, measuring 39–40 mm. as against 34·5–38 in the topotypical Oriomo series. Mammae 1–2=6. Skull more robust, the interorbital margins more angulate behind due to the more strongly flattened ridging, and the nasals relatively larger.

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[7] Ellerman.—The Families and Genera of Living Rodents, *Brit. Mus. Nat. Hist.*, Vol. ii, 1941, p. 204.

[8] Thomas.—*Trans. Zool. Soc.*, xx, 9, p. 319.

[9] Tate.—Muridae of the Indo-Australian Region. *Bull. Amer. Mus. Nat. Hist.*, lxxii, Art. vi, pp. 543-6.

[10] Thomas.—*Ann. Mag. Nat. Hist.* (7), xiv, 1904, p. 397.

Dimensions.—Holotype male, allotype female in brackets: Head and body 182 (196); tail 173 (188); pes 40 (39); ear 19 × 14 (20 × 16·5) mm.

Skull: Greatest length 44·3 (47·9); basal length 38·6 (41·5); zygomatic width 20·5 (22·3); breadth braincase 17 (17·1); interorbital 6·8 (7·3); nasals 16·6 × 5 (18·4 × 5·2); incisive foramina 7·7 × 3·5 (8·7 × 3·4); palatal length 23·5 (25·6); bulla 6·5 (6·9); molar row 7·1 (7·1) mm.

Holotype adult male M.6960, and adult female M.6987, in the Australian Museum, with a considerable series from Dobodura, Northern Division of Papua, submitted for identification on behalf of the U.S. America Typhus Commission.

Rattus gestri bunae subsp. nov.

Diagnosis.—Compared with a topotypical adult female from Rigo, S.E. of Port Moresby, of similar general proportions, but with a smaller ear and longer foot, ranging from 29 to 33·5 mm. Dorsal coloration less buffy and of a more fuscous to blackish-brown tone. Sides also less buffy, about greyish fuscous, and the entire belly more whitish, about pale smoky-grey, instead of the yellowish cream-buff of the topotypical *gestri*. Mammae 2–3=10. Zygomatic plate less prominent above, incisive foramina averaging shorter, and the molar row smaller than in true *gestri*.

Dimensions.—Holotype male, allotype female in brackets: Head and body 176 (155); tail 140 (127); pes 31·5 (29); ear 19·5 × 15 (19·5 × 13·5) mm.

Skull: Greatest length 38·5 (37·7) basal length 37·5 (34·5); zygomatic width 19·9 (19·8); breadth braincase 15·2 (14·8); interorbital 5·3 (5·2); nasals 14 × 4·2 (14·1 × 4·3); incisive foramina 8·2 × 2·3 (7·6 × 2); palatal length 20·8 (21); bulla 7·6 (7·6); molar row 7 (6·9) mm.

Holotype adult male M.7072, collected by E. Le G. Troughton: Allotype adult female M.6989, and U.S.A.T.C. spirit series, from the Dobodura District, Northern Division of Papua.

Note.—Comparison of this series with a topotypical *gestri* (mammae 2–3=10) confirms the specific distinction of *R. brachyrhinus* Tate (mammae 3–3=12), contrary to the listing of it as a race of *gestri* by Rummler. It now appears also that *aramia* Troughton, described as a race of *gestri*, actually represents a swampy race of *brachyrhinus* from the Western Division. This race is comparable with the Archbold Oriomo series, noted as somewhat different in Tate's description. Because of the externally similar appearance, and variable crania, of the two species, it seems likely that Tate's Laloki River specimens, from about 20 miles east of Port Moresby, may represent more or less typical *gestri* in which the mammary count may not have been available. *R. vanheurni* of Manokwari, on the Vogelkop of Dutch New Guinea, is a distinct species.

Rattus purdiensis sp. nov.

Diagnosis.—An insular species somewhat intermediate between *praetor* and *mordax*, but having a thinner and far less spinous pelage. Dorsal coloration much brighter, due to the greater length of the light tipping of the fur, ranging from cinnamon to ochraceous-tawny. Underparts dull greyish, the tipping from pinkish-buff (male) to pale pinkish-buff (female), and lacking the warm cinnamon to russet wash of true *mordax*, or the yellowish "olive buff" of the Bougainville race of *praetor*. Ear relatively small, attaining to 5 mm. from the posterior canthus of eye, or about half the distance to eye, when pressed forward. Tail scales rugose but relatively fine, averaging 11–12 to the cm. Mammae 2–2=8. Skull relatively smaller and less coarsely ridged than in *mordax* or *praetor*, and the nasals decidedly smaller; incisive foramina definitely smaller, and shaped more as in *praetor*.

Dimensions.—Holotype male, allotype female in brackets: Head and body 190 (175); tail 160 (125); pes 35 (32); ear 17 × 14 (18 × 14) mm.

Skull: Greatest length 42·4 (40); basal length 38·3 (36); zygomatic width 22 (21·5); breadth braincase 16·4 (16·7); interorbital 7·3 (6·3); nasals 15·8 × 4·9 (14·9 × 4·2); incisive foramina 7·6 × 2·8 (7·4 × 2·7); palatal length 23·5 (22·6); bulla 6·1 (5·5); molar row 6·3 (7·3) mm.

Holotype adult male M.7183, and allotype adult female M.7184, in the Australian Museum, from Bat Island, Purdy Group, adjacent to the Admiralty group. Collected and presented by F./Lt. D. C. Swan, R.A.A.F.

Note.—Specimens of *Rattus browni*, but none of this larger rat, were obtained by Colonel Philip and Major Kohls during brief investigations for the U.S.A.T.C. While engaged with a R.A.A.F. party upon intensive studies of the heavy mite and rat populations of the Island concerning scrub typhus, F./Lt. Swan had ample opportunity for a field study of both species of rats. He noted that the large *mordax* type burrowed strongly, and that burrows containing young had been found under boxes resting on sand. The smaller *browni* was never observed to be a natural burrower.

Rattus sansapor sp. nov.

Diagnosis.—A large sparse-haired and comparatively non-spinous rat, with the bodily dimensions of *coenorum* but the cranial dimensions of the altogether much larger *bandiculus*. Dorsal coloration between wood and clove brown, the very sparse fine basal fur showing through as an avellaneous wash; long pile hairs, up to 56 mm., projecting conspicuously over the rump-curve to beyond the tail-root. Sides drab to hair brown, washed with vinaceous buff. Belly sparsely and non-spinously haired, pale pinkish-cinnamon. Ear relatively short, reaching about half-way to eye, pressed forward. Feet sparsely pale-haired. Tail decidedly shorter than the head and body, longer in *coenorum*, scales about 8 to cm., evenly ringed, not rugosely overlapping. Skull with the bolder zygomatic plate, and stouter more expanded arches typical of the much smaller *mordax*, but having the relatively very short and broadly curved incisive foramina of the small *ringens*; the foramina, and molar row, smaller than in *bandiculus*. Mammae 2–2=8.

Dimensions.—Holotype adult male: Head and body 232; tail 198; pes 45; ear 19 × 17 mm.

Skull: Greatest length 54; zygomatic width 27·3; breadth between ridges on braincase 15·7; interorbital 7·5; nasals 22 × 7; palatilar length 26·2, palatal 30·1; incisive foramina 9·3 × 3·8; bulla length 7·4; molar row 8·3 mm.

Holotype adult male M.7195, and young paratype male M.7194, in the Australian Museum, from Sansapor on the north-west coast of the Vogelkop region of Dutch New Guinea. Collected and submitted for identification by Captain James T. Griffiths of the 26th U.S. Malaria Survey Unit, who subsequently confirmed the mammary count of eight mammae.

Rattus biakensis sp. nov.

Diagnosis.—A very large insular species, equalling the external and cranial dimensions of the mainland *bandiculus*, but with shorter pes, much narrower zygomatic width, and smaller molars. General proportions larger but the molar row relatively smaller than in the insular *jobiensis*. Dorsal coloration a dusky umber or sepia-brown tone, flecked with tawny-olive; sides buffy-brown tipped with avellaneous, merging into the soiled greyish-white of the belly, which lacks any of the warm tipping of typical *mordax* or *ringens*. Pes sparsely pale-haired, larger than in *jobiensis*, smaller than in *bandiculus*. Tail coarsely plated with overlapping scales, averaging eight to the cm. Mammae 2–2=8. Skull of similar length to *bandiculus* and *sansapor* but with a much narrower zygomatic width, and molar row decidedly smaller than in the former species; incisive foramina much larger than in *coenorum* or *sansapor*. Nasals relatively long and narrow.

Dimensions.—Holotype female: Head and body 252; tail 224; pes 45; ear 23 × 18 mm.

Skull: Greatest length 53·3; zygomatic width 23·5; breadth between ridges on braincase 15·5; interorbital 7·4; nasals 21·1 × 5·7; palatilar length 25·5, palatal 29·3; incisive foramina 10·2 × 4·5; bullae missing; molar row 7·9 mm.

Holotype old female M.7082 in the Australian Museum, collected on Biak Island, Schouten Group, by E. Le G. Troughton, on 9th March, 1935.

Note.—Evidently differing from all three large mainland forms of northern Dutch New Guinea in the combination of the short and crisp Uromyid-like pelage, and the

delicately built skull, with much narrower zygomatic width, and nasals. Differing from *jobiensis* of Japen Island in the larger pes, shorter pelage, and more umber or medium-brown coloration, and in lacking the bright reddish wash on the chin and breast, described for *jobiensis*, the mammary formula of which is not known.

Summary.

Rattus ringens and *mordax* are distinct species, as shown by Oldfield Thomas. Combination of the two by Tate, and the recording of *mordax* and *praetor* (Solomons) from south-west of the Papuan dividing range, was evidently due to a misconception regarding the type locality of *mordax*.

Inclusion by Rummler of races of *mordax* with *ringens* under the genus *Stenomys* is quite untenable, as is Ellerman's combining of the races of both species under *R. leucopus* of Cape York.

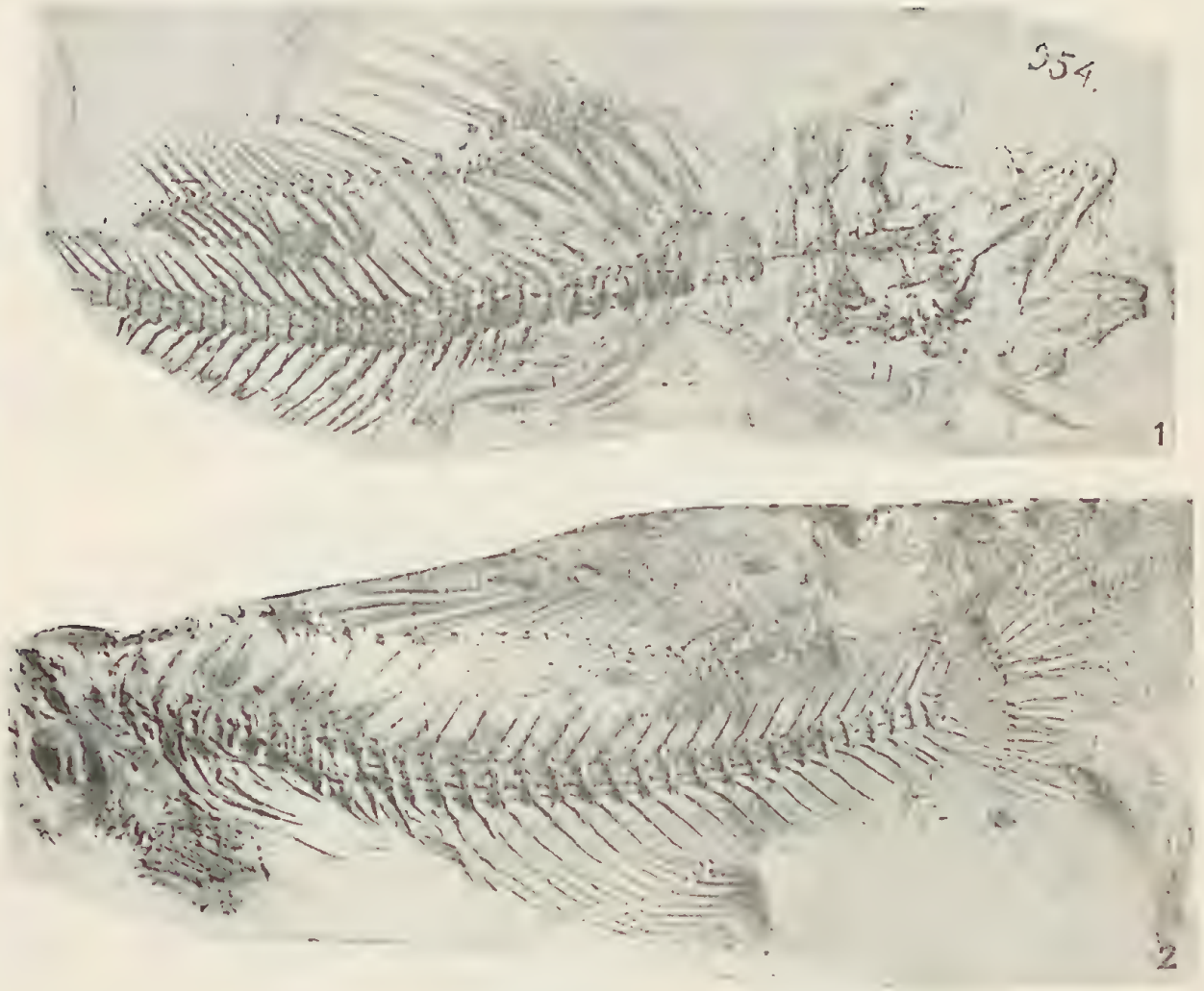
A survey of records and material indicates that *R. ringens* is naturally a lowland species with a mainly western distribution, extending from the Fly River delta, north-westward to the Snow Mountain slopes of Dutch New Guinea. No authentic specimens of *ringens* have been identified northward of the Wau–Bulolo region of the Territory of New Guinea; the more robust *mordax* becomes the dominant medium-sized species of *Rattus* in North-Eastern New Guinea.

The confusion of specific affinities by Rummler and Ellerman results partly from disregard for the diagnostic value of the mammary formulae, which affirm the distinction of *mordax* (2–2=8) from *ringens* (1–2=6), and *gestri* (2–3=10) from *brachyrhinus* (3–3=12). The mammary formula, however, may be overstressed, as doubtless in the establishing of genera from within *Rattus* by Sody.[11]

The racial alliance of relatively giant species such as *coenorum* and *bandiculus*, and the new *sansapor* and *biakensis*, with the much smaller *mordax* and *ringens*, from which they differ in various combinations of major characteristics, is quite untenable.

Apart from having the mammary formula of *mordax*, the unusually long tail and other features of *R. morotaiensis* Kellogg,[12] collected also by the author on Morotai Island, Halmahera Group, distinguish it from both *ringens* and *mordax*, and suggest affinity with a Moluccan rather than a New Guinea group of *Rattus*.

[11] Sody.—*Treubia*, Vol. 18, 2, 1941, p. 260.
[12] Kellogg.—*Proc. Biol. Soc. Washington*, Vol. 58, 1945, pp. 66-68.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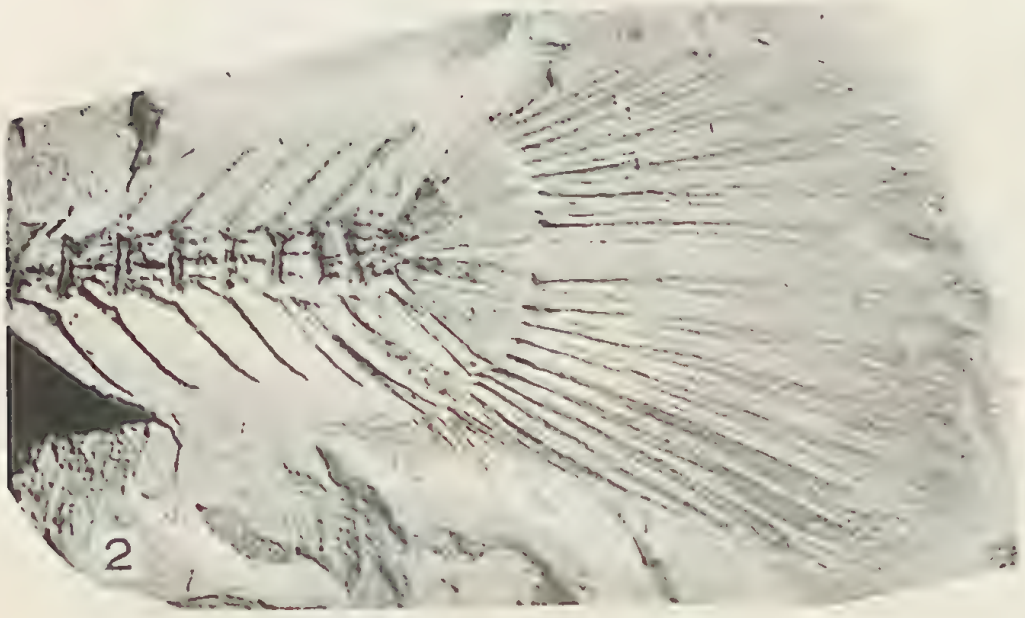
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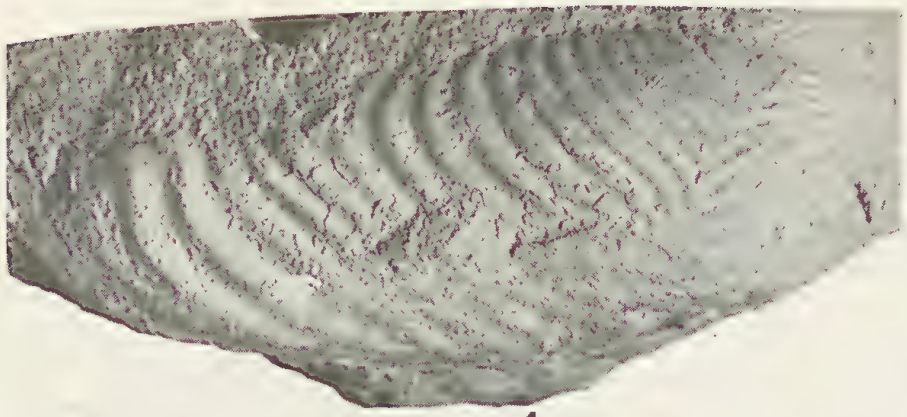

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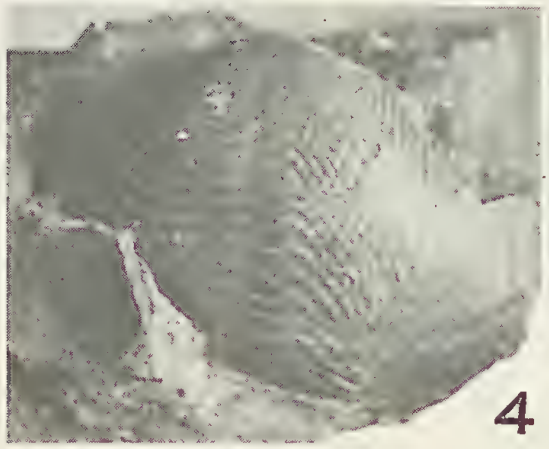

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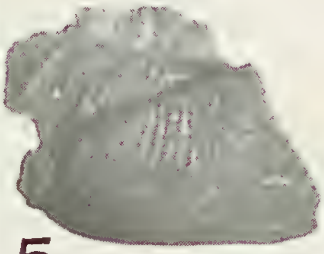

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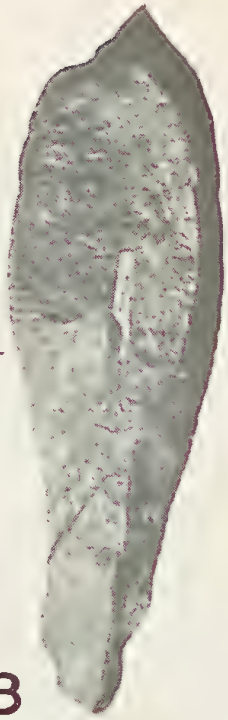

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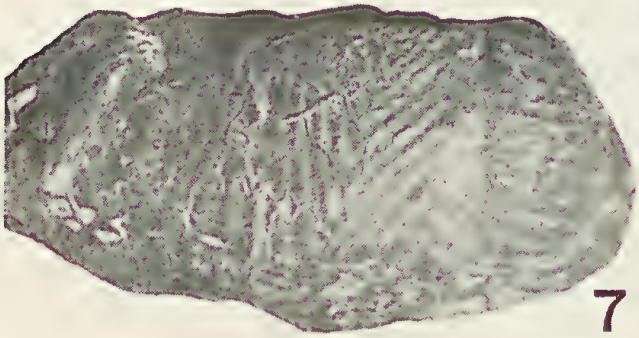

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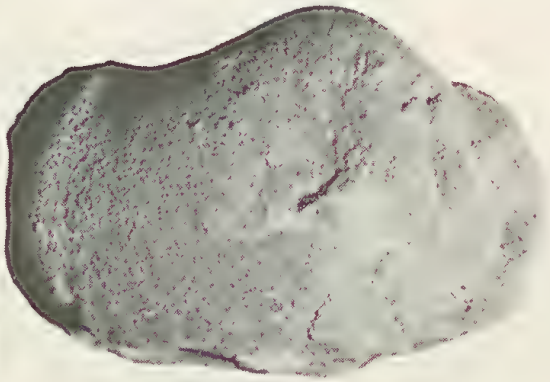

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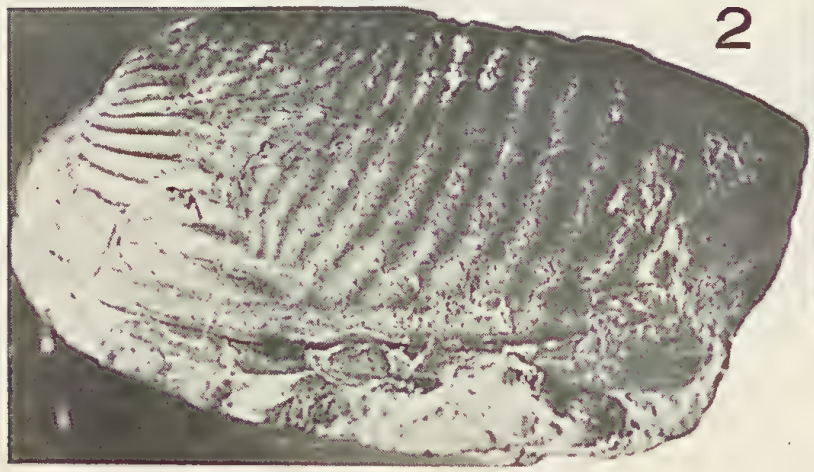

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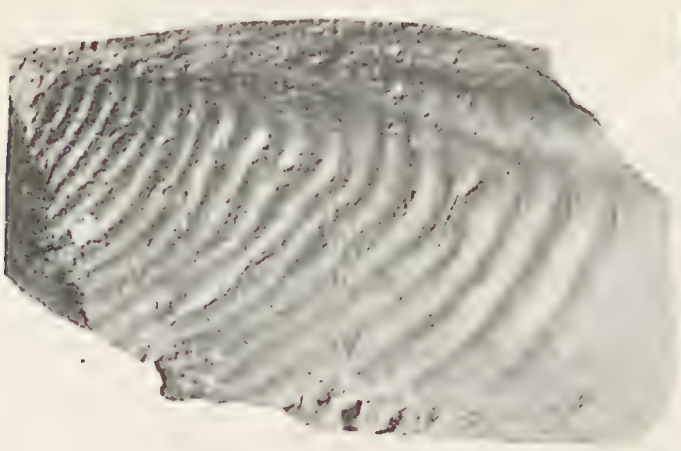

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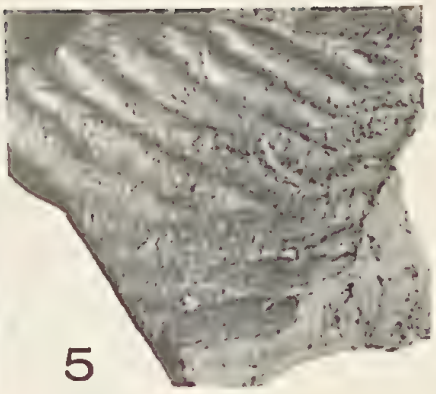

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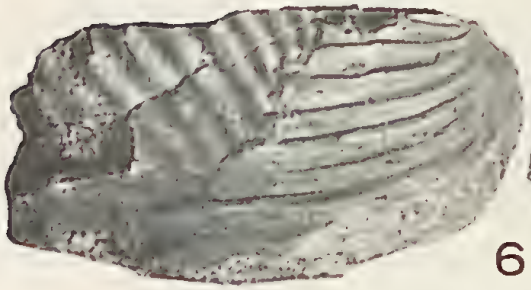

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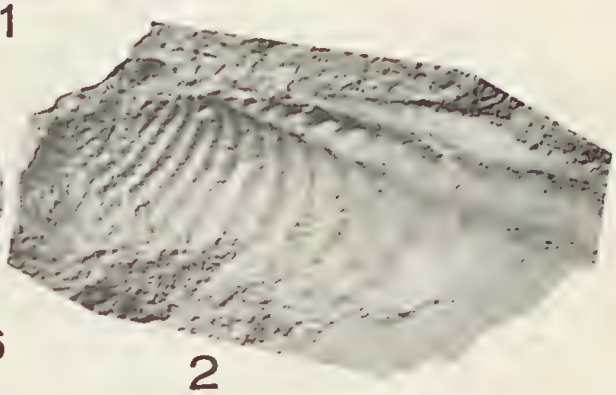

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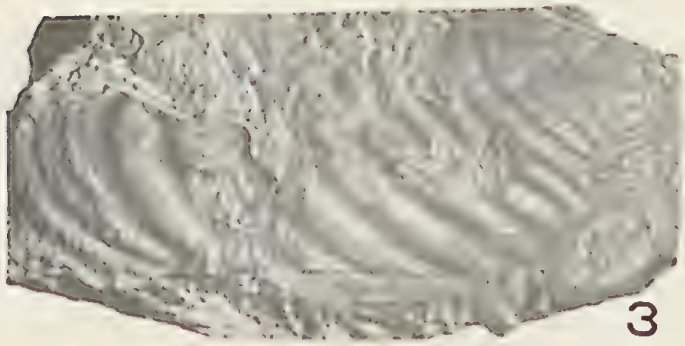

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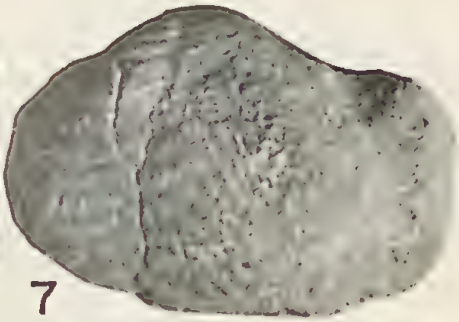

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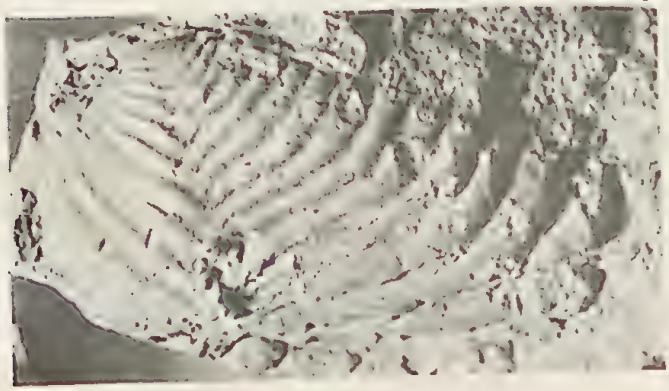

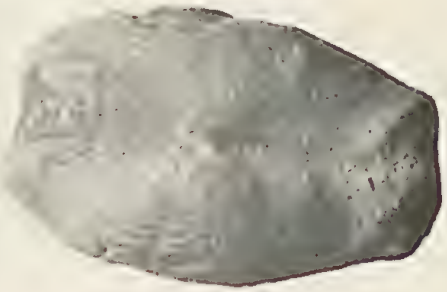

NATIONAL MUSEUM OF VICTORIA

AN ANALYSIS OF THE LARGE STONE IMPLEMENTS FROM FIVE WORKSHOPS ON THE NORTH COAST OF NEW SOUTH WALES.

By Frederick D. McCarthy.
The Australian Museum, Sydney.

(Figures 1-22, Plates xxxvi-xxxix.)

The 445 implements dealt with in this study are from aboriginal workshops at Point Plomer, Tacking Point beach, Dark Point, Anna Bay and Morna Point, on the lower north coast of New South Wales. Some of the specimens from Dark Point, Anna Bay and Morna Point were collected by the late W. W. Thorpe, and the others by the Rev. A. J. Barrett, Miss Lesley Hall and the author, while those from Point Plomer were collected during a week that I spent in the district in April, 1945. In addition, Mr. H. J. Wright, of Sydney, has kindly made available a considerable number of specimens in his collection from the three first-mentioned localities. The implements analysed comprise trimmed coroids, nuclei, blocks, *worimi* and *karta* slices, uniface pebbles, edge-ground axes, and a few normal flake and blade implements, including *clouera* and *bondi* points. This is the fifth paper of a series of analyses of sites in New South Wales from which reasonably complete collections are available.

All of the above workshops occur on the recent coastal sand-dunes, and they were apparently in use by the aborigines right up to the time of white occupation, when steel and iron replaced the stone and bone implements. This conclusion is indicated by the physiographic changes that have taken place in the area, as revealed by Dr. A. Voisey (1934, p. 342, fig. 1; 1935, pp. 88–103, fig. 1; 1939, map 1); he has shown that an

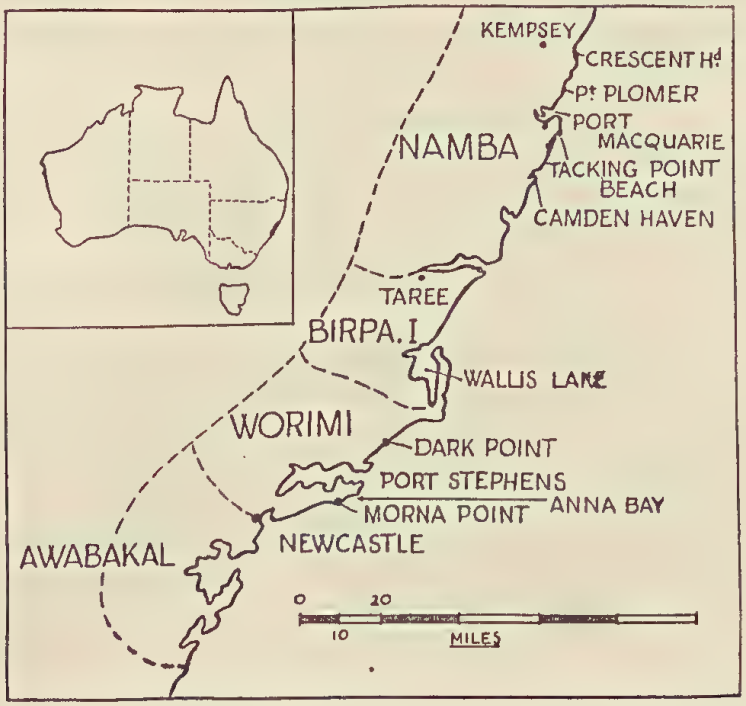

Fig. 1.—Map showing the location of the workshops herein described, and the tribes, of the lower north coast of New South Wales.

ancient shore-line existed along this coast from Tacking Point to Trial Bay and that the area, up to thirteen miles wide, between the old and new shore-lines was infilled by deposition. The old middens and feeding grounds were then abandoned and the later ones, including those described in this paper, built up along the new coast line. A description has already been given of a small number of implements (McCarthy, 1943*b*) from shell middens along this old shore-line, but it is intended to undertake a detailed study of the deposits at a later date because they may reveal important data about the prehistory of the north coast. These analyses of implements from the later workshops are submitted as a preliminary approach to the general problem of the advent of man and the implements he used in this area. Thorpe (1928, pp. 244–45 and map) drew attention to a similar problem in the Hunter River basin when he stated that "implements found above the thirty-foot contour might be ascribed to comparative antiquity", but here again detailed investigation is necessary.

Classification.—As new evidence is brought forward it is possible to gain a clearer understanding of typological problems. From data now available it is clear that the *worimi* is, technically, a slice of the cleaver type, although I have previously classified it as a block. The *karta*, as I have used the term on the coast of New South Wales, includes both slices and blocks, although they have previously been regarded as coroids.

Point Plomer.

Point Plomer is a prominent headland situated at the northern end of a beach eight or nine miles long, which extends southward to Port Macquarie. The Point consists of several high, rounded, grassy headlands, the rocky faces of which are now torn into rugged blocks and clefts by the sea and winds. The workshop is on the dunes right at the end of the beach and adjoins the southern headland of the Point. At the present time the site is limited to a trough, about one furlong long and fifty yards wide, in the dunes furthest from the beach. Previously, however, according to the late Mr. T. Dick's photographs, it covered a much larger area and extended to the back of the beach, but wind-blown sand has built up recent dunes over this eastern portion. Although no shell-midden deposit is now apparent as a layer in the dunes, there are patches of dark ashy soil to be seen. One of Dick's photographs shows a small mound thickly strewn with pippies (*Plebidonax deltoides* Lamarck), but elsewhere these shells are rather thinly scattered at the present time. Pippies are obtainable in quantity on the beach between high and low water. Here and there on the workshop are to be seen fireplaces marked by assemblies of burnt stones, some of which are suitable for grinding into red pigment. Another portion of the workshop at the base of the headland is now overgrown with grass.

The manufacturing techniques and uses of the implements at Point Plomer are discussed at the end of this paper.

Materials.—Dr. Voisey (1934, p. 340) stated that Racecourse, Delicate, Nobby's and the Big Hill headlands are composed of Permian (?) rocks of the Kempsey series, in which occur bands of sandstone, tuffs, mudstones, claystones, and inclusions of grey shale. The sandstones and tuffs vary greatly in colour, texture and composition, and may be termed tuffaceous sandstones. These remarks also apply to Point Plomer, where pieces broken off the two headlands by wave action are washed onto a small beach between them as smoothed pebbles and boulders. The aborigines took the latter to the sand dunes to make their implements. I might mention that the nature, occurrence, and use of the materials are the same at Crescent Head, about 10 miles to the north (McCarthy, 1941*c*, p. 22).

Occasional implements of a brown chert, brought from elsewhere, also occur. Merewether chert is not represented and was apparently not traded so far northwards.

Artefacts.

Coroid Implements.

Conical Implement (Pl. xxxviii, fig. 2).—The lower cortex surface is flat, but the sides and top form a domed upper surface. The butt is a flat face and the distal end tapers to a rounded point with an oblique flat face on one side. Both lateral margins are trimmed, one side being concave and roughly worked, and the other is a complementary convex edge more carefully trimmed. The whole surface is weathered. It is 32 × 9 × 9 cm. in size and 8 lb. in weight. The function of this implement is unknown, but it may be a large *worimi* in the making. A somewhat similar implement (McCarthy, 1941*b*, p. 19, Pl. lv, fig. 2) was collected on an axe quarry at Moor Creek, which is about 40–50 miles west of Point Plomer.

Uniface Pebble Implements.

Semi-Uniface.—The eleven specimens conform in all respects with the usual features of this group. On seven the trimmed edge is on a lateral margin (fig. 2), four of which are straight, two convex, and one a shallow concave 9 cm. long and 1 cm. deep. The trimmed edge forms a convex end on one and extends along the lateral margin and one end on another one. One pebble (fig. 3), 16 cm. long, bears characteristic *Sumatra*-type trimming on half of one surface, on which the parallel flake-scars extend inwards from the lateral and end margins.

There are four *Sumatra* types (fig. 4). Three display bold knapping which has produced large flake-scars at a comparatively steep angle to the flattened upper surface. The fourth specimen is a fine-grained pebble trimmed right round its oval margin, and the flake-scars are small in size; otherwise both surfaces are of cortex.

The working edges of these implements are gapped and notched as a result of use. They range from 9 × 7 × 2·5 to 18 × 9·5 × 3 cm. in size, but are up to 5 cm. thick, and from 10 oz. to 3 lb. in weight.

Nuclei.

(*a*) *Simple Platform.*—Seventeen possess one or two simple platforms and several are prismatic in shape. Some of the platforms are at opposite ends of the nuclei (fig. 14) and some are at right angles to each other. They are all small nuclei, with a flaking face 4–6 cm. long and are less than ½ lb. in weight. Very neat trimming occurs at the top of the flaking face on seven to prepare the undulating edge of the striking platform for the knapping blow. Only one has a faceted striking platform. A small number of these nuclei bear signs of use on their edges as core implements. Several nuclei collected, and others noted on the site, are pebble-cores on which the striking platform is formed by the removal of a large diagonal flake across one end; the flake-scars extend down the opposite side of the pebble.

On three conical nuclei the base is an oval fracture surface, the upper portion is domed, and the margins are convex and trimmed. The trimmed edges bear signs of use. They are from 9 × 6·5 × 6 to 10 × 8 × 7 cm. in size and 1–1¼ lb. in weight.

Two very large nuclei were collected and they are abundant on the site, particularly in the grass at the base of the headland (Pl. xxxvi, fig. 1). From this type were struck the large slices forming the *worimi*, *karta*, and block implements. One of these nuclei, of tuffaceous sandstone, is 16 × 13 × 9 cm. in size, and 4¾ lb. in weight; it is half of a boulder split into two pieces so that one side of the nucleus is a flat fracture face and the other a rounded cortex surface. The latter bears the flake-scars. The striking platform was formed by the fracturing of a block from one end of the nucleus. The second example is of chert 15 × 13 × 11 cm. in size and 7¼ lb. in weight, and is similar in formation to the other one. It has two striking platforms at right angles to one another. The large flake-scars are from 8 × 5 to 12 × 8 cm. in size.

(*b*) *Alternate Platforms.*—Two are pebbles 10–15 cm. long, with a sinuous edge along one margin formed by the alternate method of knapping. One is a pear-shaped piece which has a flat butt and is knapped along both margins and one end. One (fig. 7) is 12 × 10 × 7 cm. in size, oval in shape, and is knapped all round its periphery from both surfaces; one of the latter is ridged and in the middle of the other surface is a small area of cortex. They are 1¼–2¾ lb. in weight.

Knapped Implements.

Blocks (fig. 6).—A series of thick and irregularly shaped pieces heavily worked on the edges of their steep-faced margins. One is tongue-shaped and trimmed along both lateral margins and distal end. They are from 6 × 6 × 3 cm. to 12 × 8 × 4·5 cm. in size, and from 4 oz. to 1⅞ lb. in weight.

Slices.

(*a*) *Split Pebbles* (fig. 5).—The two examples are both about 14 × 9 × 3 cm. in size. One has the point of percussion on a striking platform at one end, and it is on a lateral margin on the other specimen. One is trimmed along both lateral margins and end, the other along one margin, both on the inner face, which is flattened.

(*b*) *Worimi Cleavers.*—In 1941 I described (1941*c*, p. 24, Pl. vi, fig. 11) a single *worimi* found on a pippy midden on Crescent Head Beach. One surface of this specimen is a fracture or inner face, the other is of cortex. I considered this cleaver-like construction of the implement to be unusual, but at Point Plomer and the other sites dealt with in the present study it is the predominant type, there being forty-nine specimens from Point Plomer alone. The angle of the two surfaces ranges from 60° to 70°. They are all large slices struck from pebbles and boulders.

Twenty-nine have the point of percussion at one end (Pl. xxxviii, fig. 3) and sixteen of them possess a striking platform. The point of percussion is not always in the middle of the platform, but is frequently towards one side or the other, and is on the corner of the butt and lateral margin of some specimens; on the other twenty specimens it is on the lateral margin of seventeen and is indiscernible on three. The inner angle ranges from 115° to 140°. The cortex surface is either flat, rounded or slightly concave.

These asymmetrical *worimi* were struck from the nucleus in such a way that the desired form, a thick-backed slice with a cleaver edge, was produced. Some consist of half a split-pebble, and one (Pl. xxxviii, fig. 4) of the largest examples is of this kind. The back was then shaped to a rounded half-oval outline by the removal of a series of flakes or by removal of one or two large flakes. On irregular examples this rough shaping may be continued round one or both ends. The lower edge of the back, that is the one formed with the inner face, is more frequently trimmed (figs. 15, 17, 19–22) than the upper edge; a common variety (figs. 15, 17) has the lower edge and one end as a continuous trimmed margin. The ends may be untrimmed. These edges show undoubted signs of use, and in some instances are worked back under the body of the implement, while one or more concaves are frequently present.

In shape the *worimi* is usually longer than wide, and they vary from the ideal segment to roughly semicircular and trapezoid specimens. The ideal form is thus a large orange segment.

The forty-nine specimens may also be subdivided according to the nature of the thin margin or chord. On fifteen this edge is smoothed and rounded by use-polish, and of them nine are convex and six straight; on these specimens the lower edge of the back and end may be trimmed so that they possess two different kinds of working edges. On nine the thin margin is convex and slightly chipped, there being small flake-scars present on both facets. On another twelve this margin is trimmed from the cortex surface as a working edge, which bears concaves from 2 to 4 cm. wide and 1 cm. deep, while one bears two rounded noses 2 to 2·5 cm. wide. On eleven this margin is a natural unused edge. Three are trimmed from the inner face with the flake-scars on

the cortex surface. One specimen in this group is of dark green chert from Racecourse Head, a few miles to the north of Point Plomer.

On ten additional *worimi* both surfaces are fracture faces. On three the thin margin is unused, and on three it is use-polished. On four it is trimmed, one having a semi-discoidal edge, and they bear concaves from 1·5 to 2·5 cm. wide, and 1 cm. deep, and rounded noses 1 to 1·5 cm. wide; three of them are heavily worked on their end-margins in addition. The largest *worimi* (Pl. xxxviii, fig. 5) in the collection is in this group, and it is 20 × 12 × 7 cm. in size and 3 lb. in weight. Two are of grey chert.

The above *worimi* range from 9 × 6 × 4 to 20 × 12 × 7 cm. in size; eight are 3·5–4·5 cm. and the balance 5–8 cm. in thickness. They range from ½ to 5 lb. in weight, the majority being 1–3 lb. All but three mentioned above are made of dark grey tuffaceous sandstone.

(*c*) *Karta.*—The twenty specimens are all slices and blocks, with a cortex outer surface. Various parts of the margins are trimmed from the inner face with the flake-scars on the cortex surface. There is a striking platform on the end of three, and on the balance the point of percussion is irregularly placed on either a lateral or end margin. The working edges are notched and irregular, and concaves of various widths appear on some of them. On several specimens the working edge is semi-discoidal, and one is a discoid (fig. 13). In shape the *karta* are mainly oval. One is an old knapped blade weathered on the inner face but re-edged at a later date. They range from 6 × 6 × 3·5 to 14 × 10 × 4 cm. in size, with one 16 cm. long, and from ½ to 2 lb. in weight.

Sundry Slices and Normal Flakes and Blades.—There is no normal flake and blade industry on the site. Although there are large numbers of flakes knapped during the shaping of the large implements, an extraordinarily low percentage bear any signs of use or trimming on their edges. Only fourteen specimens were found in several days' collecting. They comprise eight large and thick pieces, 8–11 cm. long, which are actually small slices, and five flakes 5–7 cm. long. Six of the series are trimmed on adjoining lateral and end margins, and several bear small concaves. Many possess notched edges. The point of percussion is at the end on a striking platform on the majority of the flakes on the site. Among them are numerous flakes of a poor quality light-grey chert or shale which are weathered and also blunted on the edges. The normal flake and blade implements knapped from the smaller nuclei on this workshop must have been taken away to other camp sites in the district, but the latter have not been located.

Fabricators.—No pebble hammerstones were found. Five trimmed fabricators were collected, but they are uncommon on the site. One is a tanged slice, 16 × 5 × 5 cm. in size, two are blocks, and two are coroids. Their edges are battered from percussive use. They are from 6·5 × 5·6 × 4 to 10 × 9 × 6 cm. in size and from ½ to 2½ lb. in weight.

Edge-Ground Axes.—Two of the four specimens collected are so weathered that they were left on the site, and both consist of a large elongate blade with a ground edge. The other two were retained. One is a trimmed coroid, 18 × 9 × 3 cm. in size and 1¾ lb. in weight. The other is a *windang* uniface pebble axe ground at one end on both facets and appears to have come from Crescent Head, to judge by the material. All are made of tuffaceous sandstone.

Fish-Hook File.—The only specimen found is of coarse sandstone. It is slightly convex on both surfaces and conical in shape. It is 8 × 2·75 × 1 cm. in size. This is the furthest north at which sandstone fish-hook files have been recorded, Port Stephens having previously marked this point (Thorpe, 1932, pp. 307–9, 311, Pl. xxxii).

Tacking Point Beach.

The seventy-eight specimens are from small and scattered patches of shell midden in the dunes fringing a very long beach which extends from Tacking Point, five miles

south of Port Macquarie, to Camden Haven. The principal site is at the northern end of the beach, about half-a-mile south of the Point. The implements were collected by Mr. H. J. Wright, the late Mr. E. O. Milne, and the author over a period of about twenty years.

The materials vary from fine to coarse grained cherts, tuffaceous sandstone, and others. Merewether chert is not represented.

Artefacts.

Coroid Implements.

Nuclei.—There are fourteen specimens, with one, two or three simple platforms, on three of which there are two platforms at right angles to one another. Two slender pebbles have a platform at one end. One is a thin prismatic remnant 4 × 1·5 cm., with a platform at each end, and three other remnants have a used concave 1 cm. wide on the outer edge of the platform. They are 4–9 cm. long, 1·5–7 cm. wide, and 1·5–4·5 cm. thick.

One nucleus of white quartz is biconical, with alternate knapping right round its circular margin. It is 6 cm. long and 3 cm. thick.

Uniface Pebble Implements.

(*a*) *Lateral Edge.*—This is the predominant type of large implement on the sites. The series of 26 specimens consists of well-worked and used elongate oval pebbles on which the working edge is convex on ten and straight on twelve; it is a long shallow concave on two, and there are alternate concaves and noses 1–2 cm. wide on two. The trimmed face of the working edge is steep-angled on most of them, and it is flaked back almost to the opposite margin on two. The end has been struck off one to form a striking platform from which flakes have been detached. Two are made of white quartz. They range from 9 × 6 × 2 cm. to 17 × 11 × 7·5 cm. in size and from 6 oz. to 4¼ lb. in weight.

Two additional specimens are trimmed on both lateral margins. One, 14 × 9 × 6 cm. in size and 2 lb. in weight, is keeled, pointed at one end and rounded at the other end. The other one, 10 × 7 × 4 cm. in size and 12 oz. in weight, has steep working faces with neatly trimmed edges on both lateral margins, while at one end an unused concave is bounded by two ridged spurs.

(*b*) *End Edge.*—A series of thirteen specimens somewhat smaller in size than the lateral-edged type.

The working edge is convex on five, on one of which it is like a huge nose, and is straight on three. One of the latter bears a concave 2 × 1 cm. with a rectangular nose 1 × 1 cm. The trimmed face is steep-angled on the majority. They range from 8 to 10 cm. long, 8 to 9 cm. wide, and 2 to 3·5 cm. thick, and from ½ to 1 lb. in weight.

Four specimens are more carefully trimmed than the above nine specimens. The flake-scars are long and narrow and at a very low angle, while the natural contour of the convex surface has been preserved. This distinction occurs generally among the uniface pebble implements (McCarthy, 1943*a*, pp. 131, 136). They range from 8 × 6 × 2 to 15 × 7 × 2·5 cm. in size, and from 6 oz. to 1 lb. in weight.

Knapped Implements.

Blocks.—One has a striking platform with an inner angle of 140°. There is a concave 2 × 1 cm. on its trimmed semicircular margin. The upper surface is pyramidal with a short central transverse ridge. It is 10 × 10 × 6 cm. in size and 12 oz. in weight. One has a concave 2 × 0·5 cm. on its trimmed lateral margin, and one of white quartz has notched edges. These two are 4 and 6 cm. long.

Slices.

(*a*) *Split-Pebbles.*—Of the three oval in shape, one is very neatly trimmed along both lateral margins and distal end, one along one lateral margin and end, and one on one lateral margin. The point of percussion is at the end on all three. The fourth example is roughly triangular in shape, and its long trimmed lateral margin bears signs of considerable use, there being small flake-scars along both facets of its edge; the point of percussion is at the apex. They range from 9 × 7 × 2·5 to 14 × 9 × 3 cm. in size, with one 8 cm. wide and one 4·5 cm. thick, and from 8 oz. to 2¼ lb. in weight.

(*b*) *Worimi Cleavers.*—Two are of the ideal segment form, and about 12 × 7 × 5 cm. in size and 14 oz. in weight. They are neatly trimmed along one edge of the thick back, one on the upper or cortex edge, the other (fig. 15) on the lower or inner face edge. The thin margin is use-polished on one and is trimmed from end to end from the cortex surface on the other. The point of percussion is on the end of both specimens.

The third specimen is a poorly shaped trimmed coroid of coarse pink porphyry with two cortex surfaces and a straight fracture face forming one end. The working edge is steep-faced. It is 12 × 9 × 4·5 cm. in size and 2 lb. in weight.

Normal Flakes and Blades.

Scraper-Knives: *Elouera.*—Five are trimmed on one edge only of the thick margin or back. One is a type i with the trimming on the back and plain ends; three are of type ii with the trimming extending round the distal end; two are of type iii with the trimming extending round both ends. On one of the latter the thin margin is rounded and use-polished, on three others it is scraper-trimmed, and on two it is plain and unused. They range from 3·5 × 1·5 × 1·25 cm. to 6 × 5·5 × 2·5 cm. in size.

Scrapers.—Eight irregular blades are trimmed on one straight lateral margin and two blades are trimmed on both convex margins. One of the latter has a heavily faceted striking platform. They are 4–5·5 cm. long. On a small flake 3 cm. long is a concave 1 × 0·5 cm. There are, in addition, two segments 3 cm. long, trimmed along the thick margin, but they are not geometrical microliths.

Knives.—Two of these three narrow blades have slightly scaled convex edges and one of them has a straight use-polished edge in addition. They are from 4 to 6 cm. long.

Bondi points. Six specimens from 2 to 4 cm. long.

Trimming Flakes.—One of the punch type used at both ends, and one used on one lateral margin. 4–5 cm. long.

Fabricators.—One white quartz coroid fabricator, oval in shape, 4 cm. long, on which the prominent edges of the flake-scars are battered.

Edge-Ground Axe.—The only specimen is a splendid example of the *Windang* uniface pebble axe. The blade has a broad ground facet on the trimmed surface, the other facet being cortex. A few flakes have been detached along the margins of the cortex surface by percussion use along the edges. It is 19 × 12 × 5 cm. in size, 3¼ lb. in weight, and made of tuffaceous sandstone.

Dark Point.

This headland of reddish-grey porphyry is situated a few miles north of Port Stephens and about eighty miles south of Port Macquarie. The workshop extends across the dunes behind the headland, and it is not as extensive as the one at Point Plomer. The site is very inaccessible and although a larger series of specimens is desirable, the 114 dealt with in this analysis are of particular interest because of the wide range of materials and types represented. Merewether chert was freely used on the workshop. In each group of implements the materials are widely varied.

Artefacts.

Coroid Implements.

Nuclei.—There are ten specimens with simple platforms, on five of which there is one platform, on two a platform at each end, and on three two platforms at right

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3
4
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12
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14

angles. One of the latter has one faceted platform. One is a brown chert pebble with a platform formed by a diagonal flake-scar at one end. The angle is between 75° and 80°. There is a trimmed working edge on a lateral angle on four of these nuclei. They range from 5 cm. in diameter to 11 cm. long and from 4 to 6 cm. thick.

Ten other conical nuclei with simple platform (fig. 12) form a distinctive series on which their oval and circular margin is trimmed all round. The lower surface is a flat cleavage face on nine and is of cortex on the other one. The inner angle of the striking platform by which one was detached is 135°. They are all high-crowned, and several bear a patch of cortex on their domed upper surface. Seven display heavily worked margins which are worn inwards under the body of the block, which thus overhangs the working edge. These implements conform in all respects with the *horsehoof* core implement of the interior of Australia, but the Dark Point series is much smaller in size, ranging from 5·5 × 4·5 × 4 cm. to 11·5 × 10 × 6 cm. and from 4 oz. to 2¼ lb. in weight. A wide range of materials is represented.

Among the four specimens with alternate platforms there is a patch of cortex in the middle of each surface on two, and on the third one seven flake-scars radiate from the off-centre conical point; on the fourth one the cortex is completely worked away on both surfaces. They are 6–11 cm. long and about 4 cm. thick.

One made of Merewether chert, 8 × 5 × 5 cm. in size, has a poorly formed compound platform.

Uniface Pebble Implements.

(*a*) *Lateral Edge.*—Three specimens with convex edges. On one a trimmed corner forms a large nose 4·5 cm. wide and 2 cm. deep. Two are of coarse porphyry. They are from 13 × 7 × 5 to 15 × 7 × 6 cm. in size, with one 9 cm. wide, and from 1¼ to 2¼ lb. in weight.

(*b*) *Lateral and End Edge.*—A splendid example made of a fine-grained tuffaceous shale (?). The margin is trimmed on one side and both ends to form a semicircular working edge with a steep-angled face. It is 13 × 11·5 × 6 cm. in size and 2¾ lb. in weight.

(*c*) *Sumatra-Type.*—The three specimens are made of porphyry and tuffaceous sandstone. One is an almost ideal example of the complete uniface type and is the largest of the series. They range from 12 × 8 × 4 to 17 × 11·5 × 5 cm. in size and from 1 to 2⅝ lb. in weight.

Knapped Implements.

Blocks.—All but two of the eleven specimens are elongate and flat-crowned with edges trimmed from the inner face along one or both lateral margins and sometimes also on the distal end. One, with a narrow butt and a broad trimmed distal end, is a type figured by Thorpe (1928, Pl. xix, fig. 1, and Pl. xxiii, fig. 1), from Lake Macquarie and Anna Bay. The working edges on the majority are convex, but one has a long shallow concave, and another one a series of concaves 1 cm. wide separated by pointed noses round its distal end.

One of the three keeled specimens is trimmed on both lateral margins and end. Another one, of *arapia*-type, is trimmed all round its oval margin with step-trimming on one side and a long shallow concave working edge on the other side. It is 10 × 7·5 × 5 cm. in size and 1¼ lb. in weight.

Figs. 2-14.—2-4. Uniface pebble implements with lateral and lateral-end working edges, and a *sumatra*-type. 5. Split-pebble slice trimmed on inner face. 6. Block of crown type trimmed on end and lateral margins. 7. Nucleus with alternate platforms. 8. Coroid *worimi* with use-polished edge. 9. *Worimi* with cortex back and use-polished chord. 10. *Worimi* with both lateral margins trimmed. 11. A small *worimi* with use-polished chord and trimmed end. 12. Conical nucleus with simple platform. 13. Discoid *karta*. 14. Nucleus with a striking platform at each end. Nos. 2-7, 13-14 are from Point Plomer, and Nos. 8-12 from Dark Point.

The point of percussion is at the end on three and on the lateral margin on two, the others being indeterminate. The only inner angles measurable are 130°, although one has a right-angled cortex striking platform. They range in size from a small pyramidal block 5·5 × 5·5 × 3 to a thick elongate specimen 16 × 9 × 6 cm., with one 10·6 cm. wide, and from 4 oz. to 2 lb. in weight.

Slices.

(*a*) There is one oval slice of fine-grained brown chert, with a trimmed convex edge, 13 × 9 × 3 cm. in size.

(*b*) *Split-Pebbles.*—The working edges of the six specimens are trimmed from the cortex surface on one or both margins. They range from 8 × 7 × 3 to 16 × 9 × 6 cm. in size and from 8 oz. to 2 lb. in weight.

(*c*) *Worimi Cleavers.*—An excellent series of thirty-eight specimens is represented. In shape they vary from thin blade-like examples to thick segments, a number being irregular and poorly fashioned. Fourteen are formed by a cortex surface opposed to a fracture surface or inner face, the thick back being shaped by knapping. Twenty-four possess two fracture surfaces, and on three of them the outer face consists of several large flake-scars. Four have a rounded back with cortex surface (fig. 9) and the balance are knapped to shape. On a minority the back is crescentic and carefully trimmed, but on the majority it is roughly knapped. On sixteen the inner edge of the back is trimmed and bears signs of use; on twelve this trimming extends round one end and on four round both ends. Two are trimmed on both edges of the back; one (fig. 10) of them, of Merewether chert, has step-trimmed edges, and one of fine-grained porphyry has battered edges due to percussive use, probably as a fabricator. Both are trimmed on the thin margin in addition.

The thin margin is smoothed and rounded by use-polish on ten, one of which was figured by Thorpe (1932, p. 302, Pl. xxviii, fig. 2, E.32372); on three of them the use-polish has smoothed a previously trimmed edge, but as a rule there is no trimming on a use-polished edge. On one (fig. 9) half of this margin is use-polished and the other half is trimmed, and on another one (fig. 11) both edges of the thick end are neatly trimmed to form a semicircular end joining a use-polished thin margin. On seventeen this margin is trimmed from the inner face and one from both surfaces. Nine are unused on the thin margin. One outstanding specimen was figured by Thorpe (1932, pp. 302, 310, Pl. xxviii, fig. 1, E.32371). It is made of fine-grained grey quartz-porphyry and has a cortex surface opposed to a fracture or inner face. It is well trimmed along its steep-faced thin margin and butt end, and the striking platform has been eliminated. Its working edges bear a number of small concaves and noses. It is 18 × 15 × 5·5 cm. in size and 4¼ lb. in weight. Another fine specimen (fig. 18), made of a fine-grained brown quartzite, is a perfect segment, with two fracture faces, and is trimmed on all three edges; it is 15 × 6 × 6·5 cm. in size and 1½ lb. in weight. It is as well to mention that the use-polished thin margin is often combined with one or two trimmed edges on the back of *worimi*.

On thirteen the point of percussion is on a striking platform at one end, it being of cortex on several specimens. The inner angle ranges from 123° to 140°. The point of percussion is on the lateral margin of four and is indeterminate on twenty-one, most of which are of coarse porphyry.

They are from 7 × 6·5 × 5·5 to 18 × 15 × 5·5 cm. in size and from 8 oz. to 4¼ lb. in weight.

Three coroid *worimi* will be described in this section. They are elongate, thick lumps of porphyry and tuffaceous sandstone, with flat cortex upper and lower surfaces. One has almost vertical and roughly knapped sides. The second one has one edge of one side trimmed, and above it a cortex face sloping sharply to the upper surface.

The third one (fig. 8) has one crescentic side, roughly flaked on an almost vertical face, while the lower edge of the other steep side has the most pronounced use-polished edge that I have seen on any implement; the polishing extends 1·5 cm. up the side and 0·5 cm. back from the rounded edge on the lower surface. Although trimmed coroids, these implements possess all the other characters of the *worimi* cleavers. They range from 10 × 6 × 5 to 13 × 8 × 4·5 cm. in size and from 1 to 2 lb. in weight.

Karta.—The eight specimens are oval slices 8–10 cm. long. One is trimmed from the inner face all round, and two on both lateral margins. They range from 8 to 10 cm. long and from ½ to 1½ lb. in weight.

Normal Flakes and Blades.—A small series of six knives, six side-scrapers, one with a semicircular working edge, and one *elouera* of type ii. They range from 4 to 9 cm. long.

Percussion Stones.—No pebble hammerstones are represented, but there are nine trimmed coroid fabricators, most of which are discarded nuclei with battered ridges and projections. Four are elongate and keeled, and three of them of grey chert have a poorly formed compound striking platform. Two are spheroidal and two are irregular. One trimming stone is a rectangular piece of grey chert, flat on both surfaces, with vertical sides which appear to have been rubbed on a number of facets; both edges at one end and one edge of one margin are battered. They range from 6 to 10 cm. long.

Edge-Ground Axe.—The only example is a *Windang* uniface pebble axe, oval in shape, 10 × 8 × 3 cm. in size and 14 oz. in weight. It is made of tuffaceous sandstone. Percussive use has resulted in the detachment of flakes from both surfaces along the lateral margins. The blade is ground on the facet of the inner face only, the other facet being cortex.

Anna Bay and Morna Point.

Miss Hall (1928) gave a detailed description, with a geological map, of the Morna Point site and implements, and Thorpe (1928, pp. 245–6, Pls. xx–xxii, 1932, Pl. xxviii, fig. 3) has described a number of the large implements, including *worimi* cleavers from Anna Bay. Both sites are workshops in the dunes along small beaches, each about a quarter of a mile long, flanked by headlands and outcrops of reddish-grey quartz and felspar porphyry, while andesite occurs at Point Stephens to the north and also outcrops to the south of Morna Point. The two beaches are strewn with agglomerations of porphyritic boulders, used as a source of material by the aborigines. As Miss Hall pointed out, "the swampy character of this area is due to the fact that during Tertiary times it was under water and formed part of the estuary of the Hunter River. Since that time much of the land has been reclaimed by silting associated with a recent minor uplift of fifteen feet." The high, rocky headlands which were formerly islands are now surrounded by low-lying flats, and the workshops of Morna Point and Anna Bay, as at Point Plomer, are thus on the most recent dunes.

A very interesting industry of Merewether chert normal flake and blade implements occurs at Anna Bay and Morna Point. That from the latter site was described by Miss Hall. This industry will not be dealt with in the present study, but will be analysed in a subsequent report upon the "Merewether" chert industry generally, as it extends from Tuggerah Lakes to Port Stephens and further north to Dark Point so far as is known to me, and is the predominant one in the Newcastle district on the Hunter River. This chert was traded from Newcastle a considerable distance to the north and south along the coast.

The following analysis of *worimi* slices from Morna Point and Anna Bay is given for comparison of their characteristics with those of the series from Dark Point, Tacking Point Beach, and Point Plomer.

There are twenty-four specimens from Morna Point. Nineteen are made of grey or red porphyry, which varies from fine to coarse in texture, five of light-grey Merewether chert, and one of fine-grained yellow quartzite.

Only four (fig. 16) consist of a cortex surface opposed to a fracture face on the sides. One of the chert specimens of this kind is half of a thick pebble split diagonally and laterally. The balance possess an inner face, and an outer face bearing flake-scars made prior to the detachment of the piece from the nucleus. The thick crescentic back is roughly flaked to a steep face. Some are irregular in shape, but all conform to the general orange-segment formation characteristic of the *worimi*. On a few examples the upper edge of the thick back is close to or in the middle of the outer surface on which it forms a median keel. One Merewether chert specimen is semicircular in

Figs. 15-22.—A series of *worimi* cleavers illustrating the shape, transverse section, and trimmed working edges. No. 18 possesses two fracture faces, the balance consist of one fracture face opposed to a cortex surface. No. 15 is from Tacking Point, No. 16 from Anna Bay, Nos. 17, 19-22 from Point Plomer, and No. 18 from Dark Point.

shape. Edge trimming on the thick back is present on very few of the porphyry *worimi*, probably because of its coarse and unsuitable trimming qualities, but it is well shown on three of the Merewether chert specimens, one of which has a trimmed semicircular thick margin.

The point of percussion is variously situated. It is on the end of nineteen, a minority of which possess a striking platform, is on the lower edge of the thick back of two, and is indiscernible on three. The inner angle ranges from 120° to 135°, with one at 110°.

The thin margin is use-polished on five, including one of chert figured by Thorpe (1928, Pl. xx, fig. 3), but he did not refer to this working edge. It is trimmed from the outer or cortex surface on fifteen, five of which are convex, five straight, four slightly concave, and one has a concave 4·5 cm. long and 1 cm. deep; four of this group are of Merewether chert; the remaining four are unused on this margin. Miss Hall has described and figured a number of these specimens (1928, pp. 277–78, Pl. xxxvii, figs. W1, W2, W3, Pl. xxxviii, Xi–2) and McCarthy one (1941*a*, p. 257, fig. 6). They range from 9 × 7 × 4 cm. to 10 × 10 × 7 cm. in size, and from ½ to 1 lb. in weight. There is no line of demarcation between the small light and the large heavy specimens.

Anna Bay.

There are forty *worimi* slices from this site. All but one of andesite are of red or grey porphyry, frequently coarse in texture.

Three consist of two cortex sides, nine of a cortex opposed to a fracture or inner face, and twenty-eight of a knapped outer face and an inner cleavage face. The thick back is formed in the same manner as on those from Morna Point. The distal end of one is trimmed into a semicircular edge like a large nose. One resembles very closely a lateral-edged uniface pebble implement.

The point of percussion is on a striking platform at the end of twenty specimens, on a lateral margin of five, and is indiscernible on fifteen. The inner angle ranges from 133° to 135°, with one at 140°. The thin margin is use-polished on five. It is trimmed on thirty-three specimens, twelve of which are convex, twelve straight and nine concave; six of them have one concave 7–10 cm. wide, and three have one or two concaves 1–3 cm. wide. This margin is unused on two specimens. They range from 8·5 × 5·5 × 4·5 to 16 × 12·5 × 5 cm. in size, but up to 9 cm. in thickness, and from ½ to 4 lb. in weight. Several of these *worimi* were figured by Thorpe (1928, p. 245, Pl. xxi, figs. 1–2, Pl. xxii, figs. 1–2) and McCarthy, 1941*a*, p. 257, fig. 7).

The data given above regarding the *worimi* may be tabulated as follows:

	Plomer Point.	Tacking Point.	Dark Point.	Anna Bay.	Morna Point.	Totals.	
Sides.							
Cortex and fracture	49	2	14	9	4	79	167
Two fracture	10	—	24	28	19	81	
Two cortex	—	1	3	3	—	7	
Back trimmed on							
Lower edge	27	3	16	6	8	60	167
Upper edge	1	—	—	—	—	1	
Both edges	—	—	2	—	—	2	
Untrimmed edges	31	—	23	34	16	104	
Chord.							
Use-polished	18	1	12	5	5	41	167
Trimmed	25	1	20	33	15	94	
Plain	16	1	9	2	4	32	
Point of Percussion.							
End	34	—	13	20	19	88	164*
Lateral	21	—	4	5	2	33	
Indiscernible	3	1	21	15	3	43	

* There are three coroid examples.

Dimensions.—The dimensions of 124 *worimi* cleavers from Point Plomer, Anna Bay and Morna Point are as follow:

	Length. (mm.)	Width. (mm.)	Thickness. (mm.)		Weight. (oz.)
30–9 ..	—	—	7	0–9	3
40–9 ..	—	—	39	10–9	34
50–9 ..	—	3	40	20–9	56
60–9 ..	—	15	25	30–9	20
70–9 ..	—	16	11	40–9	8
80–9 ..	5	32	2	50–9	1
90–9 ..	12	34	—	60–9	—
100–9 ..	18	15	—	70–9	1
110–9 ..	19	7	—	80–9	—
120–9 ..	27	1	—	90–9	1
130–9 ..	22	1	—		
140–9 ..	10	—	—		
150–9 ..	8	—	—		
160–9 ..	—	—	—		
170–9 ..	—	—	—		
180–9 ..	2	—	—		
190–9 ..	—	—	—		
200–9 ..	1	—	—		

This table reveals a wider dispersion in length and width than in thickness and weight, and particularly a narrow range in the two latter characters. Exceptionally large specimens are uncommon.

TABLE OF ARTEFACTS.

	Point Plomer.	Tacking Point.	Dark Point.	Sub-totals.	Totals.
Coroids.					
Sundry	1	—	—	1	1
Nuclei.					
Simple platform	19	14	10	43	
Conical platform	2	—	10	12	
Alternate platform ..	4	1	4	9	68
Compound platform ..	—	—	4	4	
Uniface pebble.					
Lateral	7	28	3	38	
End	2	13	—	15	
End and lateral	1	—	1	2	62
Sumatra type	4	—	3	7	
Blocks	7	3	11	21	21
Slices.					
Sundry	8	—	1	9	
Karta (and blocks)	20	—	8	28	
Split-pebble	2	4	6	12	153
Worimi	60	3	41	103	
Normal Flakes and Blades.					
Elouera	—	6	1	7	
Scrapers	5	10	6	19	
Knives	—	3	6	9	49
Trimmers	—	2	—	2	
Bondi points	—	6	—	—	6
Edge-ground Axes.					
Windang type	3	1	1	5	6
Biface coroid	1	—	—	1	
Percussion.					
Trimmed fabricators ..	5	—	9	14	14
Abrading.					
Fish-hook files	1	—	—	1	1
					381

In addition there are 64 *worimi* from Morna Point and Anna Bay.

TECHNIQUE.

It will be noted in the table that nuclei with simple platforms form a distinct majority, while those with alternate and compound platforms are comparatively scarce. The knapped implements do not always possess a striking platform; in fact, it is present on a small proportion only. On the *worimi* the inner angle, where measurable,

ranges from 115° to 140°, with one at 110°, which is approixmately that of the so-called Clactonian technique.

Trimmed coroid fabricators were employed as detaching hammers, and none of the pebble kind are represented. The great majority of *worimi*, *karta*, split-pebble and uniface pebble implements on the sites, as opposed to thick block types, identifies the industry as cleaver-edged, that is, one in which the predominant implements possess an acute-angled working edge formed by an outer cortex and an inner fracture face, but the cortex face is often replaced by an outer face bearing flake-scars or by a second fracture face.

The analysis throws further light upon the origin of the *worimi* cleaver. I have asserted (1941*c*, p. 25, 1943*a*, p. 139) that this thick slice implement supplanted the semi-uniface pebble implements, particularly the lateral-edged kind, and this conclusion is borne out by the material dealt with in this study. It is notable that the majority of *worimi* at Point Plomer, where they were detached from water-worn pebbles and boulders, possess an outer cortex face, but the majority at Dark Point, Anna Bay and Morna Point have an outer fracture face or one bearing flake-scars; the two latter methods of making the *worimi* are probably due to the occurrence of the material at these sites in easily procured lumps that have not been smoothed on the beach, and also to the fact that the surface of the porphyry weathers to a thick crumbly layer. It might also be mentioned that the *worimi* trimmed from the outer face on the thin margin thus possess the same type of working edge as the lateral semi-uniface pebble implements. The natives therefore were able to develop a knapping technique which enabled them to produce cleavers either from the abundant large water-worn stones or from lumps of rock obtained from outcrops. This process merely required an adaption of the simple split-pebble technique they already employed, as on the comparatively small pebbles of Tacking Point beach, where semi-uniface pebble implements predominate and *worimi* are scarce.

So far as I know, the *worimi* cleaver does not occur on Kangaroo Island, but in size and form it is similar to the large lateral-edged uniface pebble implements so abundant on this island.

Thorpe (1928, p. 243) considered the *worimi* to be a percussive tool used for breaking open molluscs to expose the shellfish, but my analysis of the working edges reveals that the *worimi* was rarely used for percussive or battering purposes.

Discussion.—The Point Plomer and Dark Point workshops are of particular interest in being confined chiefly to the production of large implements of the cleaver and chopper kinds. The *elouera* industry (McCarthy, 1943*a*, McCarthy and Davidson, 1944) prevails along the coast from Port Stephens southward to the Victorian border and probably beyond. It might be mentioned here that the Australian Museum possesses an oblique trimmed blade, 2·25 cm. long and 1·75 cm. wide, with a faceted butt, from Fingal on the Tweed River; it is actually a variety of *Bondi* point, and indicates that the *elouera* industry might be found on scattered sites on the north coast. Tacking Point also has yielded one *elouera* and some *Bondi* points, but is unimportant for purposes of comparison. It is also important to note that the specialized uniface pebble implements, the *worimi* cleaver and implements of the Kartan culture form part of the *elouera* industry on southern workshops, and the further claim (McCarthy, 1941) that the *elouera* normal flake and blade industry is a later development than the Kartan uniface pebble industry appears to be supported by the segregation of the latter on North Coast workshops. One reason for the latter situation is that the high mountains of the Great Dividing Range probably formed a barrier which preserved the North Coast as a backward cultural pocket. The Dark Point and Plomer Point sites belong to the Yamba and Crescent Head (McCarthy, 1941*c*) group, and it is probable that similar workshops exist near many other headlands on the north coast. Furthermore, the North Coast sites at which the *worimi* cleaver predominates should be regarded as

local variants of the Kartan uniface pebble culture, with the addition of the edge-ground technique and fish-hook files. The *horsehoof* core implement occurs with this culture on Kangaroo Island and the sites herein described.

One other point of importance is that most of the axes found on the workshops at Crescent Head, Point Plomer, Tacking Point beach and Dark Point are of the *Windang* uniface pebble type (McCarthy, 1944), an occurrence which supports the conclusion that this axe is a transition type from the trimmed to the ground edge. Curiously enough, pecked and grooved and biface coroid edge-ground axes are ploughed up on farms along the alluvial banks of North Coast rivers. Two pecked axes from the Port Macquarie district were presented to the Museum by Mr. Pountney in 1945.

The use-polished edge, to judge by its common occurrence on the *worimi* cleaver, is the result of a special use of these implements. The first explanation of the manner in which this edge is produced is the cleaning and scraping of skins for cloaks, and another one is the scraping of the rough outer shreds from the sheets of bark used for making canoes, shields, and containers. The scraping of wooden weapons and implements could also produce such an edge. Only experiment will demonstrate which of these suggestions is correct. It must not be forgotten that the use-polished edge occurs not only on large implements like the *worimi*, but also on normal flakes and blades such as *elouera* and unspecialized kinds.

Point Plomer Implements.

The Australian Museum possesses a collection of photographs of the Port Macquarie natives, made by the late T. Dick, whose observations extended from 1890 to 1927 in his daily occupation as an oyster-grower and fisherman on this estuary. He took a kindly interest in the local aborigines, especially in their problems arising from contact with the whites, but he also made a deep study of their customs. So sincerely did they respect him that he was able to get them to make replicas of their weapons, domestic articles like bags, baskets and bark containers, and canoes, ornaments and skin cloaks, pubic aprons and ritual objects, and with these and the old specimens that he had collected they re-enacted various aspects of their daily and ceremonial life. In addition, he wrote a manuscript embodying the information he collected, but unfortunately this work and his collection of specimens, including those shown in the photographs, cannot now be traced by the surviving members of his family.

Among the photographs are about fifty in which stone implements are shown. The majority of these were taken at Point Plomer, others in the mangrove swamps along the western and southern shores of Port Macquarie, and a few elsewhere in the district. In assessing the value of these photographs insofar as their accuracy is concerned it must be remembered that they are not of natives living in their original primitive state, but of more or less civilized individuals re-enacting the past. T. Dick had the benefit of information from his father, J. S. Dick, who had lived in the district for sixty years and had seen the natives using stone tools. Settlement was established at Port Macquarie in 1821, and it can be accepted without doubt that from this date onwards metal axes and other tools, and bottle-glass, were given by the settlers to the natives to gain their goodwill and to pay them for services rendered. Henderson (1851, ii, p. 148) said that all of the natives in contact with whites on the Macleay River had steel axes, and T. Dick himself stated in 1915 (p. 283) that the Stone Age was almost immediately replaced by the Metal Age. Dick's photographs were taken between 1914 and 1927. It is probable that none of the old men whom he knew had any first-hand knowledge of the manufacturing techniques, nor of the precise functions of the implements, and further, that none of the natives shown in the photographs had any practical knowledge of the Stone Period. This is an important point to establish and it appears to be clear that the subjects illustrated are an expression of the combined knowledge of these customs possessed by Mr. T. Dick

and his native friends. Their names and ages, so far as they are known by his son, Raymond Dick, who knew them personally, are as follows: Charlie Murray, between 65 and 70 years of age; Peter Budge, between 70 and 75; Neil Morcom, 40; and Ted Dungay, 40; Mrs. Murray, Mrs. Dungay.

Raymond Dick told me that Murray and Budge knew a great deal about the traditional life of their people, and probably about stone implement manufacture, but both were born after 1850. Mr. T. Dick is to be commended very highly for his admirable effort to preserve a knowledge of the past with these photographs, but for the sake of accuracy it is necessary to evaluate them in the light of present-day knowledge, because they illustrate both doubtful and authentic methods of manufacture and uses of stone implements in this area. The following remarks are not, therefore, a criticism, but merely an impartial review of the evidence presented by Mr. Dick.

No less than five photographs show the placing of pebbles on the fire for fracturing purposes (Pl. xxxvi, fig. 2), but none of the implements collected show any signs of having been in the fire, moreover, the presence of a striking platform, point and bulb of percussion on the majority of specimens, each struck by one blow, appears to rule out the employment of the heat-fracturing method in the old days. Thorpe (1932, p. 302) conjectured the use of this method in the Newcastle district. Actually, the effect of fire on tuffaceous sandstone and chert is to soften the stone.

Two methods of knapping are shown and these are probably correct. They are both variants of direct rest percussion (Holmes, p. 300, fig. 163). Pl. xxxvi, fig. 1, demonstrates the removal of large flakes from a massive nucleus set upright on the ground by striking it with a large two-handed knapping stone. Pl. xxxvi, fig. 3, shows a widespread method of knapping, that in which the nucleus is placed and held firmly in one hand on an anvil stone, while the hammerstone is held in the other hand. Pl. xxxvi, fig. 4, illustrates the latter technique applied to a working edge, but the implement should be lying flat on the anvil stone to make it possible to trim the edge. These are obviously implements picked up on the workshop and not made by the natives shown in the photographs.

None of the photographs shows direct free-hand fracture (Holmes, 1919, p. 284, fig. 144) recorded by Roth in Western Queensland (1904, p. 16, fig. 23) but it was probably employed in trimming and shaping implements.

The only other technique illustrated is that of grinding the blades of axes, which incidentally, appear to be *windang* uniface pebble types picked up on the workshop. Pl. xxxvii, fig. 3, shows the grinding being done on an outcrop of sandstone (?) at Green Hills, twelve miles south of Port Macquarie. Raymond Dick has informed me that there are no axe-grooves at this site. Another photograph shows the use of the sand-covered surface of a pebble for the purpose; I did not collect any pebbles bearing axe-grinding grooves, but Raymond Dick has informed me that his father collected several examples. It might be mentioned that in other parts of New South Wales this process produces definite grooves up to 30 cm. long, 5–8 cm. wide, and 4 cm. deep. Portable whetstones from 7 cm. to 30 cm. long, bearing a groove, are widely distributed in Australia.

In regard to the uses of the implements the same feeling of uncertainty exists as to whether or not these natives really knew the exact or correct type of stone implement to use for the various operations illustrated. The photographs are, however, valuable in demonstrating a wide range of the known uses of stone implements, and furthermore, they are, so far as I know, the only series in existence dealing with the coastal natives of New South Wales. Both Kerry's and Lindt's photographs are of physical types and ceremonies, and they do not illustrate stone implement techniques and uses. Pl. xxxvii, fig. 2, shows the use of a hand-scraper or graver on a boomerang, and in several other photographs a carved club is substituted.

To my knowledge there is no record of the use on the north coast of New South Wales of a stone adze-flake or a shell-chisel mounted on either the end of a spear-thrower or a wooden handle. Enright (1900) does not mention it in his review of the material culture of Port Stephens. Further south, the hafted shell-chisel was recorded by the First Fleet historians in the coastal area between Botany and Broken Bays, a hafted stone adze-flake was used by the *Buruberongal* horde in the area where the Hawkesbury River joins the Nepean (Hunter, 1793, p. 452), and Bradley (1788, October, pp. 129–130) recorded the use of a stone adze secured in a similar manner to the axe-blade in describing the stone implements of the Sydney district.

In a series of twelve photographs (some of which have been published—Dick, 1915, and Goddard, 1934) is shown the cutting of a sheet of bark and wood to a depth of three inches from the trunk of a mangrove tree. Dick's remarks (pp. 283–88) on the uses of the stone tools are as follow:

"On investigating the result of the work of the stone axe on the Grey Mangrove a vast field was opened up, as not only was the work done by the stone axe revealed, but there was also brought to light the method and locality where these axes were made . . . In the Stone Period the shields were cut with stone implements only, and this period must have extended over a very long time, as shown by the variety of shapes of the axes and cutting stones found at the bases of trees. from very crude unground stones with cutting edges made by splitting only, to the ground-edged implements. The former are actually the shivers off water-worn boulders weighing over one hundred pounds, and in many cases so many shivers have been taken from the original stones that the unused part now only weighs a few pounds . . . The late John Stuart Dick of Port Macquarie had often seen the natives removing the shields in the early days of the settlement by stone tools only . . . and by steel tools as well. It was the information given by this Mr. Dick that led to the search amongst the trees, as he often drew my attention to those which were marked . . . Mr. E. H. Dick saw a native using a steel tomahawk and wooden wedges . . . The wedge was of special stone found in the district, and shaped similarly to the gads used for bursting stone, only the point was not made fine, but on the contrary, it was blunt and would not enter timber. The rabbet was cut to take the point of this wedge, and to allow this wedge to be driven into it, and so derive great lifting power . . . eight or nine wedges were driven into the rabbet and when the tree was hard, there would be a number of wedges destroyed and dropped, and these can be found at the present time by digging round old trees. To get the lifting power the wedges were made practically double the width of the rabbet into which they were to be driven. The shield, having been removed, would be carried to the camp, where with smaller wedges and cutting stones its manufacture would soon be finished . . . In cutting the rabbet, two kinds of stones were evidently used, one of them was a shaped and ground axe made from stone and another was formed to fit the hand, and was not ground, the edge being kept keen by chipping the blade. In several instances ground axes from which part of the face had jumped out were found at the foot of the tree . . . Two natives (pl. xlix) are shown engaged driving the peculiar bluff wedges into the special rabbet, the man on the left is handing up the wedge to the native on the right, who is driving them in with a stone hammer or maul."

Bradley (1788, Oct., pp. 129–30) said that the natives of the Sydney district used a hatchet and an adze both secured to a stick with gum and lashing, and a wedge, all of the same kind of stone. A junk of wood was used as a mallet or maul. These tools, he continues, all appear to be used in providing the canoes and shields from the trees, by cutting the bark to the length required to enter the wedges and leaving it in that state some time before the sheet was removed. The natives were seen engaged in this work. Unfortunately, Bradley did not illustrate these implements.

As Dick's specimens are not available, it is not possible to identify definitely his so-called "bluff-wedges" in the collection from Point Plomer dealt with in the present study. The *worimi* cleaver with a trimmed end would serve the purpose of blunt-ended wedges. None of the *worimi* from the workshop sites herein described display any signs of battering on either end or on the thick back such as would be present had they served as wedges driven into a rabbet. Furthermore, their principal working edges are on the thin margin or chord and on the lower edge of the thick back. Figures 17, 19 and 21 could be used as wedges. It must not be forgotten that the *worimi* were undoubtedly used on the workshops, where they were collected, for other

purposes. Thus Goddard's claim (1934, pp. 192–93) that the wedge-shaped choppers, now termed *worimi* cleavers, were used as wedges in the cutting of shields is feasible but still open to doubt. He found five massive flaked implements of this kind and some chippings at the base of old mangrove stumps along Tilligery Creek, Port Stephens, and two others of diabase in the vicinity of Yellow Jacket or flooded gums at Kelvin, where an old resident, Mr. G. Urquhart, told him that the natives preferred this tree for shields.

Other implements that would form wedges are the lateral- and end-edged uniface pebble implements, which are rare at Point Plomer and common on Tacking Point Beach, and also the rather scarce end-trimmed blocks. I spent a day digging round the bases of the mangrove trees bearing shield-scars in the area where Dick's photographs were taken, but I failed to locate any wedges, and digging on a deeper and wider scale would have to be carried out. The collecting of a series of wedges, many of which would be broken and all of which should show percussion marks where they were struck with the mallet, is the only conclusive way to identify the type. Perhaps the most suitable implement among those in the industry to serve as a wedge is the edge-ground axe.

The uses of the hafted axe shown in Plates xxxvii and xxxix are probably correct, although some of this work is carried out with hafted adze-flakes or hand choppers in other localities. They comprise cutting the grooves on a tree round a sheet of bark for a canoe (Pl. xxxvii, fig. 1), cleaning the loose and stringy outer bark off the sheet (Pl. xxxvii, fig. 4), cutting a gnarl from a tree-trunk for a container (Pl. xxxix, fig. 1), and cutting a design in a dendroglyph (Pl. xxxix, fig. 2). Hafted axes were also employed as hammers and mallets on their butt, but not on their sharpened edge, to drive in wedges as shown in Pl. xxxviii, fig. 1. Just how many edge-ground axes were picked up by Mr. T. Dick at Point Plomer will never be known nor will their types, but Raymond Dick has told me that they were not uncommon on the workshop when he visited it with his father, and also that a genuine hafted axe from Rolland's Plains, near Port Macquarie, was used in the various operations photographed.

Acknowledgments.

My sincere thanks are tendered to Mr. Raymond Dick for the generous assistance that he has rendered in connection with this study, to Mr. H. J. Wright for the loan of specimens, and to Mr. G. E. Binsted for his excellent drawings of figures 1–22.

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EXPLANATIONS OF PLATES.

Plate xxxvi (Point Plomer).

Fig. 1.—Knapping flakes from a large nucleus.

Fig. 2.—Placing a pebble on a fire to split it into pieces.

Fig. 3.—Natives on the workshop, knapping flakes and shaping weapons.

Fig. 4.—Trimming a lateral-edged uniface pebble implement.

Photographs by the late T. Dick.

Plate xxxvii.

Fig. 1.—Cutting a groove round the trunk with a hafted stone axe in the process of removing a sheet of bark for a canoe. Port Macquarie.

Fig. 2.—Shaping a boomerang with a knapped scraper. Point Plomer.

Fig. 3.—Grinding axe-blades at Green Hills.

Fig. 4.—Removing the stringy outer bark with a hafted stone axe on a sheet intended for a canoe. Port Macquarie.

Photographs by the late T. Dick.

Plate xxxviii.

Fig. 1.—Cutting out a shield with stone implements. This tree is still standing in the mangrove swamp on the south-western shore of Port Macquarie. (Photograph by the late T. Dick.)

Fig. 2.—Large conical implement, Point Plomer.

Fig. 3.—Inner face of a large *worimi* cleaver, Point Plomer.

Fig. 4.—Outer face, showing the trimmed lower edge of the thick back of a large *worimi* cleaver. Point Plomer.

Fig. 5.—The largest *worimi* cleaver from the Point Plomer workshop. It has a fracture face opposed to a trimmed face. (Photograph by G. C. Clutton.)

Plate xxxix (Port Macquarie).

Fig. 1.—Cutting a gnarl from a gum tree with a hafted stone axe.

Fig. 2.—Cutting a design on a tree with a stone axe-head.

Fig. 3.—Cutting up a dolphin with a stone knife.

Photographs by the late T. Dick.

A NEW FOSSIL HOMOPTERON FROM KIMBLES HILL, BELMONT (UPPER PERMIAN).

By J. W. Evans.
(Imperial Institute of Entomology, London.)

(Plate xl and Figure 1.)

The single fossil wing described below is the only one of any special interest, belonging to the sub-order Homoptera, which has been brought to light as a result of recent search in Upper Permian strata in New South Wales.

Division AUCHENORRHYNCHA.
Family PERMOGLYPHIDAE.
Stenoglyphis, gen. nov.

The tegmen is long and narrow and has a circular lobe at the base; the costal space is narrow and R_s is undivided. The first branching of M occurs in the proximal half of the tegmen; M_1 has four branches, and M_2, M_3 and M_4 are all undivided. Cu_1 is short and Cu_{1a}, which meets the margin of the tegmen only slightly beyond its centre, is bent. Reticulate cross-veins occur between several of the principal veins, and the clavus (which is unknown) extends for only a third of the total length of the tegmen.

Stenoglyphis kimbiensis, sp. nov.
(Fig. 1 and Plate.)

Length of tegmen, 36 mm.; greatest width, 10 mm. The venation is obscure towards the apex of the tegmen; this may be due to incomplete preservation, or it may represent the actual condition of the tegmen, the weakness of the veins being associated with the apical overlap of the folded tegmina.

Holotype tegmen—F.41206 (positive impression)
F.41207 (negative impression) found by Mr. O. Le M. Knight at Kimbles Hill, Belmont, New South Wales.

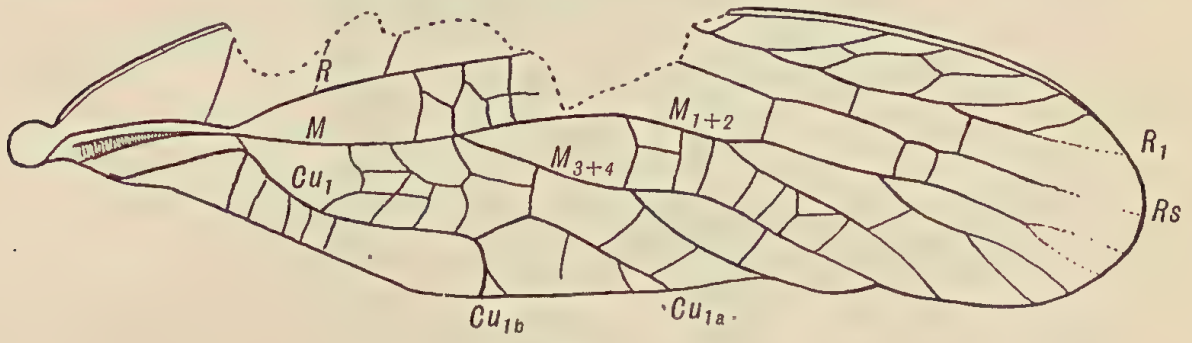

Fig. 1.

Discussion.

With a few exceptions, such as *Eochiliocycla angustata* Davis (1942) and *Stanleyana pulchra* Evans (1943), the tegmina of all Upper Permian Auchenorrhyncha have a characteristic feature in common. This feature is the steep bend in the proximal part of Cu_1 and the close approximation, without actual fusion, of the bases of the three principal veins.

The tegmen of *Stenoglyphis kimblensis*, while having the character mentioned above, is nevertheless quite unlike that of any other tegmen previously described from Upper Permian strata and is only temporarily referred to the Permoglyphidae. It resembles *Permoglyphis belmontensis* Tillyard (1926) in the narrowness of the costal space, in having reticulate cross-veins and in the presence of a basal pad. It differs from *P. belmontensis* in the shortness of the unbranched portion of the media, in the shortness of Cu_1, and in the size of the clavus. Further, it is probable that *P. belmontensis* had tectiform tegmina, unlike *S. kimblensis*, which almost certainly had overlapping tegmina.

The most notable feature of the tegmen of *S. kimblensis* is its size, which exceeds that of any previously described Upper Permian Homopteron, although certain Prosbolids from the Upper Permian of Russia approach it in this respect.

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EXPLANATION OF PLATE XL.

Photograph of *Stenoglyphis kimblensis*, sp. nov. Kimbles Hill, Belmont, New South Wales. Photo G. C. Clutton.

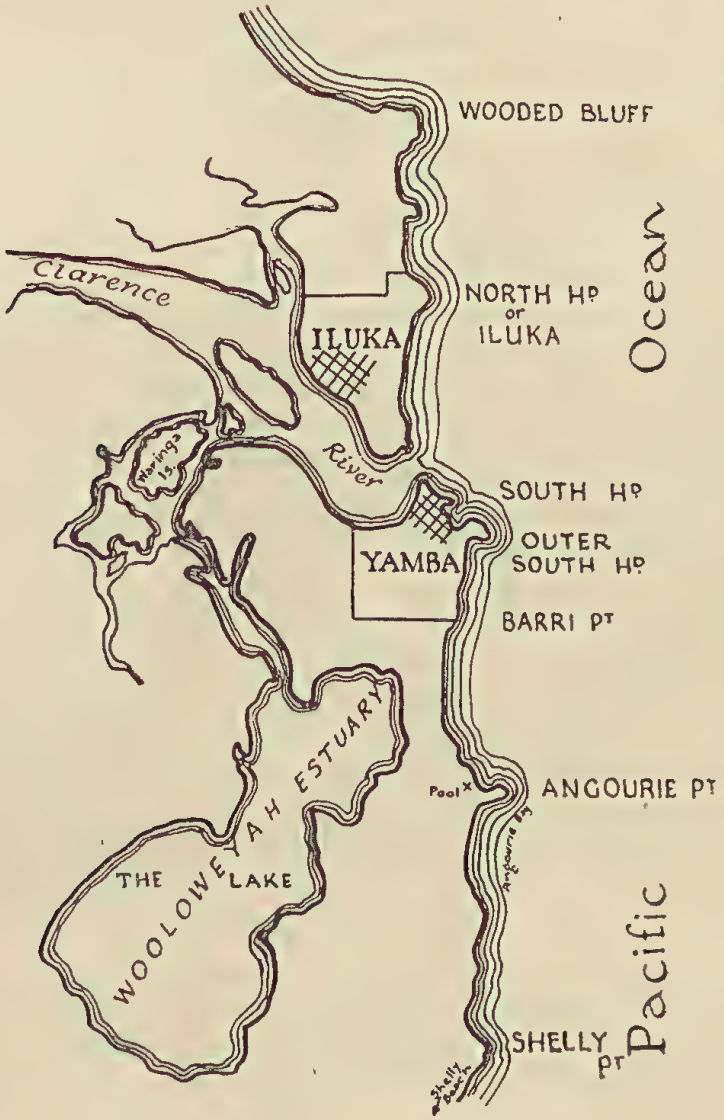
NUDIBRANCHIA FROM THE CLARENCE RIVER HEADS, NORTH COAST, NEW SOUTH WALES.

By Joyce Allan.
The Australian Museum, Sydney.

(Plates xli-xliii and Map.)

Introduction.

In June, 1941, the Clarence River Heads, north coast of New South Wales, were visited for the purpose of collecting certain marine molluscan material, in particular, Nudibranchia. For some time Mr. A. A. Cameron, of Harwood Island, Clarence River, had forwarded to the Museum marine specimens from this locality, a considerable proportion of which had indicated the presence there of a strong, extra-Australian tropical influence of ecological and zoo-geographical importance. The nudibranch material was particularly interesting in this respect, since the majority of the rare species he had forwarded were collected in a restricted area, the Angourie Pool, a



small excavation in the rocky shore shelf at Angourie, a popular fishing spot. The trip was therefore undertaken to investigate the molluscan fauna in that locality, with special attention to the preparation of field notes and colour sketches of the Nudibranchia encountered.

A considerable variety of both tropical and temperate rocky shore shells was present in all areas visited—in one locality alone, Shelly Beach, no less than eleven species of cowries were noticed in an hour or so. Notes only were kept of the various species of molluscs seen, as the main concentration was to be on the Nudibranchia, which forms the basis of this paper. However, a collection was also made of several other very interesting Opisthobranchia, including species of Aplysiidae, and Lamellaridae, which it is intended to deal with at a later date.

Mr. Cameron not only gave every assistance by arranging transport at that end and acting as an enthusiastic guide to all the spots, but helped considerably with the actual collecting, and much of the success of the trip is due to his untiring efforts in this direction. My thanks are here tendered for his consideration and the interest he has always shown in this particular molluscan group. I should like to thank Mrs. D. Cameron also for the colour sketches she has prepared on occasions in the past, and Mrs. L. Woolacott and Miss G. Thornley for similar kindnesses while they have been holidaying at Angourie. My thanks are also due to Miss Betty McKinnon, of the Lands Department, Sydney, for preparation of the map.

Unfortunately, squally rain and very cold conditions, with heavier seas than had been experienced for many years along that part of the coast, continued during the two weeks of collecting and made the work most difficult and at times very unprofitable. Dredging was out of the question. The only attempt at this was abandoned early, owing to the adverse conditions. Fishing boats were often unable to operate, and the nets, when they were put out, brought in little material of personal interest, but fragments of coral, sponges, and other marine organisms clearly indicated the coral reef influence adjacent to the shore. Lobster pots were set down on several nights, but collected only common rock shells.

Collecting was confined generally to the Angourie Pool, with a few short trips to nearby grounds, Angourie Point, Green Point, Shelly Beach and Woody Head, all regarded as excellent collecting spots. Their principal features are detailed later.

Only one new species of Nudibranchia was found. But of far more importance than the establishment of new species was the predominance of tropical species (some of which are rare even in their type localities) which are now recorded from Australia for the first time, linking up a definite Africa-Indo-Pacific relationship of a significance not fully appreciated before amongst the nudibranchs. One family, Caliphyllidae, three genera, *Cyerce*, *Baeolidia*, and *Peronodoris*, and sixteen species have been added to our list as a result of this collecting. Amongst the species, six *Glossodoris*, out of a complement of nine *Glossodoris* collected, are new records. When the unfavourable conditions existent at the time—conditions which normally drive many nudibranchs out of collecting range—and the fact that the majority of rarer species came from a restricted pool not more than 60 feet long are taken into consideration, the result is somewhat amazing.

Throughout this paper the general classification is along the lines adopted by Thiele, and reference is made in the text to any doubtful points in this regard when necessary.

Character and Relationships.

Hedley, Iredale and others have indicated in various papers on zoo-geographical relationships of molluscan fauna the presence of an invading tropical fauna into Australian waters. Hedley (1893, p. 189) indicates that there appears no definite temperate and tropical division as a result of this invasion. This fauna gradually

dwindles southwards and the southern fauna moves northwards, but no definite line exists; the species along the coastline merely overlap, and in many places are found side by side. An excellent example of this may be found at Shellharbour, south coast of New South Wales, where living specimens of *Strombus luhuanus*, a typical coral reef shell, thrive in company with characteristic southern and mid-coastal species.*

A stream of tropical Papuan marine life (much of which is itself associated with other Indo-Pacific material) flows in fairly undiminished strength until it reaches the border of New South Wales, where, as Hedley points out (op. cit., p. 189) "the cooler climate diminishes its vigour, and at the Clarence River, N.S.W., with few exceptions, it finds its southernmost limit". From then on the tropical material becomes reduced in numbers, and in varieties of genera and species, until there are only tropical strays which have been able to survive the colder conditions of the south. As much as in any other marine group, the Nudibranchia on the eastern coast of Australia have demonstrated this invasion, a demonstration which has been considerably strengthened by examination of the collection made in 1941, at the Clarence River.

In recent years dredging in Sydney Harbour has revealed a prominent strong tropical element amongst the molluscan fauna (Iredale, 1929, p. 337). Material dredged by the *Triton* in particular has led to the supposition that there is a relict fauna there, apart from recent invaders, a reminder of the times when Sydney Harbour enjoyed a more tropical climate. Hedley has shown that tropical forms have incessantly attempted to colonize our coast. When the Notonectian current floods the harbour these gain a footing, though many perish when the stream swings off-shore. This probably explains, to some extent, the presence of many of Angas's species of Nudibranchia in Sydney Harbour, when in reality they are of more tropical nature, their range being Indo-Pacific, or even Africa-Indo-Pacific.

The present collection of Clarence River Nudibranchia lends further support to zoo-geographical relationships suggested in the past. As pointed out above, the relationship between them and those of the Africa-Indo-Pacific region is strikingly emphasized. Such species as *Elysia marginata*, *Peronodoris tuberculata* and *Glossodoris reticulata* are known to range through the Indo-Pacific to East Africa; *Glossodoris decora* and *G. inornata* to Japan and the China seas respectively; *Dendrodoris denisoni* to India and Japan, and *Baeolidia major* to Zanzibar and Japan. Strangely, *Dendrodoris guttata* has been recorded only from Western Australia and Japan previous to its Clarence River occurrence; no other record of it has appeared elsewhere from the Indo-Pacific. The presence of *Glossodoris geometrica* in the Clarence River collection is surprising since this species seems known only from New Caledonia, where it is apparently rare. Other instances of zoo-geographical relationships are indicated throughout the text.

In a close comparison of species, it is seen that this material and that of New Caledonia are very similar, the majority of the species having been recorded by Risbec and others from that island. A number of the Clarence River species have as their type locality the Sandwich Islands; it would be interesting to ascertain how far their eastern range extends and what relationship they bear to those from the west coast of America. Their relationship to the Lord Howe Nudibranchia is also interesting. The marine fauna, in general, of that small island has shown a close connection with that of New Caledonia and a slightly weaker one with the Australian fauna. Several

* Since writing the above I have received a copy of "Notes sur les peuplements littoraux d'Australie" (Soc. de Biogeographie, vii, 1940, pp. 289-313) by P. H. Fischer. In this study Fischer (p. 290) suggests that a distributional limit of true tropical and temperate molluscan littoral fauna on the east coast of Australia is reached at approximately Cape Sandy, Queensland. Prof. T. Harvey Johnston (Q'land Nat., Vol. ii, No. 2, 1917, p. 63) found a meeting ground of tropical and temperate fauna at Caloundra; in some groups the former predominated, in others it was the latter, but on the whole he found the southern element (temperate) was the stronger.

species of nudibranchs collected there have now appeared at the Clarence River, and rather notably, *Cyerce nigra*, var. *ocellata* Bergh, which also occurs at Samoa and in the Indian Ocean (Eliot).

This Lord Howe Island–New Caledonia relationship with Clarence River Nudibranchia is more clearly understood from the deductions of Iredale and Allan (1940, p. 45) in a study of the relationships of the mollusca of Lord Howe Island, in which the land connections between it and New Caledonia and the evidence of a land bridge or series of stepping stones connecting New Caledonia with southern Queensland by way of the Capricorn group are discussed. The influx into New South Wales would be consequential, as indicated earlier.

There is obviously a coral reef pocket off-shore from the Clarence River. Much of the marine life brought up in fishing nets, and frequenting the rocky shore at low-tide level, reveals this. This is apart from drifting objects from tropical islands of the Pacific carried along the route of the trade winds (Hedley, op. cit., p. 191). The nudibranchs collected in a restricted area during a few weeks, despite weather conditions which usually prove most unfavourable for their appearance, amply support this and lead one to suspect that there may exist there a far larger number of tropical species of this group than expected.

As further molluscan collections are made in Australia it should become apparent that many species previously regarded as more or less confined to these waters have, in reality, a wider range, and their zoo-geographical relationships will probably remove them from the ranks of separate species into the synonymy of older species. A perusal of even this small collection has demonstrated this possibility. This will be fortunate, since it will check much of the unnecessary splitting of species which in recent years has caused so much trouble to conchological workers.

Localities.

Yamba, about 40 miles by road from Grafton. No material of interest was found on its headlands and fine beaches.

Angourie Point.—A small headland a few miles south of Yamba. It consists of many fine rocky shelves, with numerous pools, weed-covered rocks, and narrow gutters, and is an excellent spot for general marine collecting. Owing to the heavy storms, masses of heavy kelp and bead weed (*Hormosira*) were piled over the rocks. The absence of nudibranchs here, in contrast to the abundance of other marine life, is consistent with their general behaviour under heavy storm conditions. It has been frequently noticed also, and was conspicuous during this trip, that nudibranchs do not favour association with the heavy growth of bead weed which is frequently found in certain exposed locations.

Angourie Pool.—The main purpose of the trip was to investigate the nudibranch fauna in this pool. It is undoubtedly a favourable collecting spot for this group. The pool is situated at Angourie, just immediately north of Angourie Point, and separated from it by a short, sandy beach. It is a pool in the rocky shore shelf jutting out between two beaches and is an old quarry in the shelf, from which rock was removed to make the breakwater at Yamba. It is somewhat below sea-level, and is dependent on the tides pouring in water through cuttings in the rocks at the south end and washing over the flatter, lower rocks at the north end. An ample supply of fresh salt-water is continually maintained in the pool, which is quite free of stagnation and contains abundance of healthy weed growth. Water seeps back into the sea through cracks in the rocky face of the pool. At the north end the heavy rains had caused a slight freshet from the land bank into the pool, and it was noticed that the water in that immediate vicinity was slightly clayey and the marine life had retreated more towards the centre of the pool.

The pool is about 60 feet long and about 15 feet wide, running parallel to the shore. The bottom stratum is sandy, almost devoid of mud, with masses of various sized rocks, profusely covered with short weed growth, an environment admirably suitable for many nudibranchs. The sheltered, calm position of the pool, and the almost complete absence of bead weed and giant kelps enable all types of Opisthobranchia to thrive, and they appear the dominant animal life in the pool. Although other marine types are present, their numbers are insufficient to affect this group. Common molluscs, typical of rocky shores, are also present, the principal ones being the loricates, periwinkles, limpets, and occasionally a cowry or two. The pool seems workable irrespective of tides and practically in all weathers. Only during the heavy seas ranging at that time had it been noticed covered completely with water. On very few occasions does it fail to produce an interesting species, since fresh Nudibranchia swept in by the strong seas breaking over the rocks at high tide are able to exist there in safety. At this particular time many of the marine organisms in the pool were breeding.

Shelly Beach is situated about five miles south of Angourie and is reached by a strenuous walk along stretches of sand and very rugged coast or by a rough cart track through thick bottle-brush country. It is regarded as one of the best collecting grounds on that portion of the coast and usually repays the visitor who is prepared to make the journey. It is a favourite haunt of cowries, as will be seen from the fact that no less than eleven species were seen in an hour or so, some of them in large numbers. The rocky shelves exposed at low tide abound with pools, weed-covered rocks, and numerous gutters and cracks, in places teeming with many varieties of marine tidal life. Here again the seas had brought in masses of giant kelp weed and the rocks were covered with a profusion of bead weed, as noticed elsewhere.

Green Point is north of Angourie Pool and separated from it by a sandy beach. It did not yield any material of importance at this time, but appears a good collecting ground.

Woody Head (*Wooded Bluff*).—North side of the entrance to the Clarence River, about eleven miles from Yamba. It is an excellent collecting ground. The low rocky shelves exposed at low tide abound with marine life of considerable interest and variety, most of which displayed a strong Indo-Pacific influence. Some very interesting nudibranchs were found there and a record made of the value of this place as a collecting ground. The weather encountered on the two days spent at Woody Head was the worst experienced during the trip, and it speaks well for the marine life inhabiting this zone that such a profusion was noticeable in spite of heavy rain and biting, cold winds, which swept over the area. Bead weed was again much in evidence.

Summary.

The results gained from the study of this collection of nudibranchs may be summarized as follows:

Many interesting species have been added to the Australian list.

A much closer relationship between the Australian and the Africa-Indo-Pacific Nudibranchia, in particular those of New Caledonia, than previously estimated has been shown.

Several uncertain genera and species have been established and some species reduced to synonyms.

Some of Angas's species from Sydney Harbour have been shown to be tropical wanderers, whose more normal habitat is an Indo-Pacific range.

The coral reef influence off the Clarence River makes the locality an extremely important one for ecological and zoo-geographical study of its marine fauna.

The advantage and importance of studying nudibranchs and allied groups in the field, with preparation of colour notes and illustrations, have been further emphasized. More complete descriptions of several hitherto uncertain species, in particular those of Angas, Pease, Abraham and Kelaart, have been made possible.

Family CALIPHYLLIDAE.

Genus Cyerce Bergh, 1871.

Cyerce Bergh, 1871, p. 113. *C. elegans* Bergh, Philippines.

Tropical Opisthobranchia recognized by the numerous rows of large, flat, leaf-shaped cerata grouped along the sides of the body. The sole of the foot is divided. Rhinophores bifid. Teeth denticulate, forming an irregular heap in the radula sac. Vent dorsal.

A genus established by Bergh for drawings of species made by Semper in the Philippines. There are two principal species in the genus, *elegans* and *nigra*. This family, and the Elysiidae, though often grouped, in a general way, with the Nudibranchia in papers of this nature, belong to the order Sacoglossa, which is very close to the Nudibranchia.

Cyerce nigra var. ocellata Bergh, 1873.

(Plate xli, figs. 1–3.)

Cyerce nigra var. *ocellata* Bergh, 1873, pp. 83–86. Samoa.

Animal velvety-black, *head* and *body* lined and spotted with orange-yellow. *Cerata* black, with broad orange-yellow band of colour along the upper margin, and numerous orange-yellow pustular spots on both the upper and lower surfaces. The spots on one side of the cerata are confined to several irregular rows towards the edges, and on the reverse side are scattered completely over the surface and not wholly confined to the marginal areas. When alive, the animal is extremely beautiful, but in preservative most of its brilliancy has gone and many of the cerata have become detached from the body.

Measurements.—Approximately two inches in diameter when the cerata are fully expanded. Two specimens.

Locality.—Angourie Pool, crawling on the rocky side of the pool.

The typical *Cyerce nigra* has yellow or orange-red spots on one side of each cera, but on the reverse side the spots are replaced by transverse lines of the same colour. Eliot (1903, p. 572) recorded the variety *ocellata*, which differs from the typical *nigra* in having spots on both sides of the cerata, from Minikoi (Indian Ocean). The Angourie specimens conform to the variety *ocellata*.

In a paper in the course of preparation this species is recorded from Lord Howe Island. This is, however, its first record from the Australian coast.

Family ELYSIIDAE.

Genus Elysia Risso, 1818.

Elysia Risso, 1818, p. 375.

Body very flat, sides winged, and a cardio-renal protuberance present. Surface smooth.

Elysia australis Quoy and Gaimard, 1832.

Actaeon australis Q. & G., 1832, p. 317. Sydney Harbour.

This tiny, olive-green species, delicately spotted with creamy yellow, and with violet-tipped rhinophores, and violet border to the mantle lobes, was found on numerous occasions in Angourie Pool. As a rule several specimens were found together, attached to fine weed. It had been noticed in the pool before and has since been found on several occasions. The species is very common round Sydney, but its small size and its habit

of associating with self-coloured weed render it most inconspicuous. This is the first record, as far as I am aware, of the species being found so far north.

Angas (1864, pp. 69–70) described this same species as *Elysia coogeensis*.

Elysia marginata (Pease), 1870–1.

(Plate xli, fig. 7.)

Pterogasteron marginatus Pease, 1870–1, p. 304. Sandwich Islands.

A single, beautiful specimen of this species was collected on a small rock at low tide in the Angourie Pool, 5th June, 1941. When alive it was extremely graceful and active, and the movements of its softly undulating mantle lobes were fascinating to watch.

The mantle is almost lettuce-green in colour towards the foot, but much darker, almost blackish-green, near the mantle edge. The slender neck and head are pale green. Along the edge of the mantle lobes is a rich, velvety-black band of colour, followed by a narrow white line, then a broad orange-red line. The whole body is covered with scattered black speckles, some larger than others, interspersed with white ones. The anterior end of the foot has a white edge and there are white splashes along the sides of the lobes, foot, and on the *rhinophores*. The stout rhinophores are ear-shaped and slightly involute, with narrow white edge, below which is a broad black band, followed by a narrow orange one.

This is the first record of the species from Australia, although previously I had recorded it from Middleton Reef, east of the New South Wales coast (Allan, 1937, p. 262).

Eliot (1904–5, p. 296–7) shows the variation in the colouring of specimens of this species from Zanzibar, and also draws attention to its close proximity to that of *E. nigrocincta* Bergh, 1873. I also feel that *E. grandifolia* Kelaart (1859, p. 493) is simply another variation in colouring of the species, and possibly also *E. punctata* Kel. which is described immediately below it and which seems merely a young form of *grandifolia*. Then again, a species described earlier by Pease from the Sandwich Islands, *Pterogasteron ornatum* (1860, p. 36), seems to be the same, and his lack of reference to it when describing *marginata* from the same region may lead one to think he had overlooked his earlier species. *P. ornatum* would have preference over *marginata*, but should *grandifolia* eventually prove synonymous, then it has preference over the other specific names.

Taking into consideration the degree of colour variation the Opisthobranchia appear to exhibit over a geographical range, the following species seem sufficiently close to consider their synonymity with *marginata*: *ornata* Pease, 1860, *grandifolia* Kelaart, 1859, *punctata* Kel., 1859, and *nigrocincta* Bergh, 1873.

Risbec (1928, p. 280–281) records a species as *E. ornata* (Pease) from New Caledonia. This resembles our species which, however, appears to be the typical *marginata*.

Family POLYCERIDAE.

Subfamily POLYCERINAE.

Genus Plocamophorus Leuckart, 1828.

Plocamophorus Leuckart, 1828, p. 17.

Body limaciform. Head veil bearing tubercles or branched appendages to the margin, and two or three processes on each side of back. Gills few, non-retractile.

Plocamophorus imperialis Angas, 1864.

Plocamophorus imperialis Angas, 1864, pp. 59–60. Sydney Harbour.

A typical example of this species was found in the Angourie Pool. The combination of its red and purple colouring, with dark spotting, and its elaborate structure, make it

one of the most beautiful of our nudibranchs. This is the first record of the species so far north along the New South Wales coast, although a specimen has since been collected at Angourie. The species occurs only rarely round Sydney, but when it does appear, several are usually found during the period of its occurrence, which is usually November to January.

Family DORIDIDAE.

Subfamily GLOSSODORIDINAE.

A subfamily composed of numerous species, abundant in the Indo-Pacific.

Genus Glossodoris Ehrenberg, 1831.

Glossodoris Ehrenberg, 1831, p. 92.

Elongate animals, with narrow mantle edge covering the head, but not the posterior part of the foot. Surface generally smooth and frequently ornamented with brilliant colours in the form of spots or lines. Gills many, simply pinnate.

Glossodoris bennetti (Angas), 1864.

(Plate xli, fig. 4.)

Goniodoris bennetti Angas, 1864, pp. 51–52. Port Jackson.

This brightly ornamented *Glossodoris* frequently appears round Sydney and north and south along the immediate coastline, where it is usually found at low tide crawling on weeds or under stones in rock pools. It is an extremely handsome species.

Our specimen was collected on the 6th June at Shelly Beach, just south of Angourie Point. Although only a small specimen, three-quarters of an inch in length, it agrees with those frequenting the type locality. It has the same azure-blue body-colour and magenta-red spots on the dorsal surface, round the margin of the mantle, and scattered along the sides of the foot. The rhinophores and the ten gills are red. The mantle has a vivid yellow border.

Although one of the commonest nudibranchs of the central New South Wales coastline, this species of *Glossodoris* does not appear to have been recorded from New Caledonia or other South Pacific localities, where an associated nudibranch fauna has been noticed. The species had not been noticed in the vicinity before.

Glossodoris daphne (Angas), 1864.

(Plate xli, figs. 11–13.)

Goniodoris daphne Angas, 1864, p. 54. Port Jackson, N.S.W.

This provides a northerly record for this species. It is rarely found, even in the type locality.

The white body, dotted dorsally with scarlet, has a double border (the outer scarlet, the inner orange) to the mantle, which immediately identifies it with *daphne*. As in the type, the gills and rhinophores are scarlet. The coloured border shows through to the under-surface of the mantle. The foot is white and a white tail protrudes well beyond the posterior portion of the mantle when the animal is crawling. The rhinophores are pedunculate, whitish along their stalks, finely lamellated, with about twenty-four lamellae. Gills (10) simply pinnate, linear, the posterior ones smaller. Orals linear. Mantle border and edge of foot wavy. The pink spotting on the dorsal surface and the coloured border show up vividly against the white background. The rhinophores are partly retractile in spirit, the gills not at all.

Measurements.—1½ inches long, ¾ inch broad (crawling).

Locality.—Angourie Pool, on weed. 12th June, 1941.

This beautiful *Glossodoris*, which is rarely found along the coast, provides another instance in support of the necessity of recording the colours of live nudibranchs.

Although the specimen has preserved well, every vestige of contrasting coloration has vanished and the animal is now a dingy cream. As it appears at present, it might be any one of several species.

The species approaches *Glossodoris marginata* (Pease) [1860, p. 30] from the Sandwich Islands, but the latter seems to lack the scarlet spotting on the dorsal surface. Risbec (1928, p. 133) and Baba (1938, pp. 11–12) record *marginata* from New Caledonia and Japan respectively, but neither of their descriptions refers to any coloured spotting on the dorsal surface. It may be considered, therefore, that these two species are distinct or, if related, the spotted southern form is a variety of *marginata*. Winckworth (1946, p. 157) points out, however, that *Glossodoris* (*Doris*) *marginata* Pease is preoccupied by *D. marginata* Montagu, 1804, and *D. marginata* Q. & G., 1832.

Incidentally, Winckworth (p. 156–7) describes a new species, *Glossodoris trimarginata*, from Bombay, which, except for the white edge to the mantle, closely resembles *G. daphne*. The species known as *marginata* Pease apparently requires a new specific name.

Glossodoris geometrica (Risbec), 1928.

(Plate xli, fig. 14.)

Chromodoris geometrica Risbec, 1928, pp. 148–151. New Caledonia.

This beautifully marked little *Glossodoris* is obviously Risbec's species. There is slight variation in colouring, which is not unusual when purples, reds and yellow predominate, as they do in this species. A short account of the Australian species, as in life, is as follows:

General colour light fawnish-yellow, with a dark purple-red line round the border of the upper surface of the mantle, continuing down each side, with off-shoots towards the mantle edge. These cross-lines enclose areas which have the appearance of pustules. On the main line are scattered creamy-white spots. Violet lines are on the upper surface of the tail. The rhinophores are set well back and are orange-yellow with a green tinge. There are seventeen long, slender, simply pinnate gills, cream at the base, and orange-yellow for their greater length. They are retractile into a circular cavity. The mantle is fairly wide. The dorsal surface is firm and rather flat, with a few large, indistinct pustular areas, with fawnish-yellow lines encircling them. A dark violet line runs round the upper end of the mantle, fading away just below the level of the rhinophores. The undersurface is creamy-white. The anterior end is broad and laminated, and the orals long and cream-coloured.

The rhinophore cavities in both preserved specimens are elevated. In one specimen the gills have completely retracted into a slightly tubular cavity, but in the other they are exserted. The gills diminish in size towards the posterior ones, which are very small.

Measurements.—Approximately 22 mm. long, 8 mm. broad. Two specimens.

Locality.—Angourie Pool, low tide under rock, amongst weeds.

Both specimens are now stained uniform deep reddish-purple. As far as I know they are the only specimens recorded, other than those forming Risbec's New Caledonian species. It is one of the most interesting species in the present collection.

Glossodoris decora (Pease), 1860.

(Plate xli, figs. 8–10.)

Doris decora Pease, 1860, p. 29. Sandwich Islands.

Glossodoris setoensis Baba, 1938, pp. 12–13. Japan.

Ten specimens of this very attractive species were collected at low tide in shallow water in the Angourie Pool on 4th June and following days. The species had not been

seen previously in the locality, and provides a new record for Australia. It is extraordinary that it should be so common at this particular time.

The striking colour pattern of the dorsal surface provides a strong distinguishing feature, as will be seen in the following brief description.

An elongated, smooth, gelatinous animal, with mantle rounded anteriorly. Gills fairly slender, simply pinnate, seven in number, the posterior ones in some specimens very small, giving the impression of only five gills. The gills decrease in size posteriorly. Rhinophores long, elongate-oval, their lamellated portion as long as their peduncles; retractile into simple cavities. Foot narrow, rounded anteriorly, extending to a tail point, well beyond the mantle margin, when crawling. Orals small, digitate.

The general body colour is cream to straw colour. The central dorsal surface of the mantle is conspicuously marked with three longitudinal, opaque, white stripes. The medial one runs down the centre from between the rhinophores and bifurcates about 3 mm. before the gills, the two branches running round and uniting behind the gill chamber. Similarly this line divides anteriorly, encircling the rhinophores connecting, sometimes disjointly, with a similar white line which runs down each side of the dorsal area, uniting posteriorly in some specimens. The mantle margin is creamy yellow-orange, interrupted by bluish-white patches of colour. Inside this, and between it and the lateral white lines, is an interrupted band of reddish-purple (puce), extending round the head and tail. The rhinophores and gills are dirty white. The foot is a gelatinous bluish-white, with a single row of small reddish spots which may show through from the dorsal surface.

The ten specimens showed slight variation in the depth of colouring round the mantle border, but the three white lines and the bifurcation of the medial one are constant. In preservative, the colouring has disappeared, but the white lines stand out against the now dusky body colour, and with the rhinophores and gills retracted, form a quaint pattern on the soft surface (fig. 10).

Measurements.—The largest specimens measured 25 mm. long and 5 mm. broad, when crawling, but some were slightly smaller.

This Australian *Glossodoris* certainly seems to be *Glossodoris setoensis* Baba, from Japan, but unfortunately Pease had earlier described *decora* from the Sandwich Islands, which, except for slight variation in the colouring of the mantle border, appears the same species. Though unaccompanied by an illustration, Pease's description permits the species to be identified without difficulty and leaves little doubt that *G. setoensis* Baba is a synonym of it. *Glossodoris lentiginosa* (Pease), 1872, pp. 18–19, seems to resemble this species also, but the medial line does not bifurcate, and the purple dots over the dorsal surface seem more profuse than on *decora*. It may be a colour variation of the latter.

Glossodoris inornata Pease, 1871.

(Plate xli, figs. 5–6.)

Chromodoris inornata Pease, 1871, p. 18. Huaheine Is. (Society Is.).
Chromodoris tenuis Collingwood, 1881, pp. 130–1. East China Seas.

The difference between *inornata* Pease and *tenuis* Collingwood is so slight that their separation seems quite unwarranted. Priority is given to *inornata* as the earlier name. Collingwood's colour illustration and that of Pease coincide, except that the latter shows fewer violet spots on the dorsal surface and does not indicate the orange-coloured line round the foot. Risbec (1928, pp. 129–131) describes and figures as *Chromodoris tenuis* a rare species from New Caledonia, which is certainly similar to our species. He may not have been aware of Pease's species, as he does not refer to it in relation to his species.

When crawling, the animal elongates considerably and is very beautiful. A bright orange-coloured line borders the pure white mantle and foot, and the dorsal surface

and sides of the foot are splashed with small violet spots. The rhinophores are orange and the gills are light coloured, tipped with violet and yellow. The gills are simply pinnate, and number seven, but some are slightly divided at the tips, which gives the impression of extra gills. Orals yellow.

Measurements.—Average length 35 mm., breadth 7 mm. Capable of considerable extension (50 mm.) when crawling.

Locality.—Angourie Pool, under a rock at low tide, 5th June. One specimen. This species had not been seen before in the locality, nor to my knowledge elsewhere along the coast. It is recorded from Australia for the first time.

In common with some other species of *Glossodoris*, the above animal had the ability to intensify or diminish its colouring at intervals, in particular the border and spots.

Eliot (1908, p. 111) considered *inornata* a closely allied form of *Glossodoris pallida* (Ruppell & Leuckart, 1828) from the Red Sea, of which he makes *G. marginata* (Pease, 1860) a synonym. However, I can see no resemblance between the two species to justify them being regarded as closely allied. I have seen several specimens which can be definitely determined as *inornata* as designated by Pease, and *tenuis* by Collingwood, and in none of these does the double-coloured border encircle the mantle. The other colouring is distinct also. The species regarded by Risbec as *tenuis* from New Caledonia is decidedly referable to these and not to *pallida*, or *marginata* as established by Pease. The brief description and figure of *pallida*, given by Ruppell and Leuckart, exhibit little to substantiate Eliot's decision to place *inornata* in its synonymy.

Glossodoris mariei (Crosse), 1872.
(Plate xli, fig. 15.)

Goniodoris mariei Crosse, 1872, p. 73. New Caledonia.

One very small specimen of this species was found under a stone at low tide at Woody Head on 10th June. It was between ½ and ¾ inch long and ¼ inch broad.

The general colour of the animal is white, with an orange-coloured border, interrupted with white, round the mantle. Violet spots are scattered over the dorsal surface, principally towards the centre, and the rhinophores, ten gills, and oral tentacles are violet tinged. A violet line outlines the foot and tail.

Although Crosse draws attention to a slight resemblance between his species and some of the Australian forms described by Angas, but from which they differ specifically, there appears to be no species described from Australia with which *mariei* can be associated with certainty. *Goniodoris festiva* (Angas) is somewhat like it, but the yellow line in that species is entire and the spotting, rhinophores and gills are rose-carmine in colour, not the rich violet shade of the Woody Head species, or as described by Crosse for his species. *Glossodoris splendida* (Angas) also bears some resemblance to the species, but the colouring and the size of the spotting are different.

Glossodoris sannio (Bergh) (1888, p. 939), from Amboina, seems to me to be very close to *mariei* and may be synonymous. Eliot (1905, pp. 248–9) records *sannio* from Maskat. The only important difference between the two species appears to be the presence of some tubercles on *sannio*. In observing the living *Glossodoris*, however, the tendency of coloured spots on the body of the animal to rise like tubercles has frequently been noticed, and this may be the case in *sannio*.

Risbec (1928, p. 71) places *mariei* in the genus *Doridopsis* (= *Dendrodoris* Ehrenberg), as the specimens he collected in New Caledonia were without jaws or radula. Unfortunately our small specimen is very hard and brittle and I have been unable to discover whether there is a radula or not. However, in life it certainly was a typical *Glossodoris* in outward structure and colouring, and until further material comes to light it is left in this genus. It is certainly not a characteristic of *Dendrodoris* to have numerous simply pinnate gills.

Glossodoris reticulata (Pease), 1866.

(Plate xli, figs. 18–20.)

Goniobranchus reticulatus Pease, 1866, p. 205. Pacific Islands.
Chromodoris alderi Collingwood, 1881, p. 132. North Formosa.

The above two species are undoubtedly synonymous. Specimens collected at Angourie Pool under stones at low tide on June 4th and 12th respectively showed variation in the intensity of the orange and red colouring, and slight difference in the colouring of the gills and rhinophores, that of the latter date resembling more Collingwood's illustration of *alderi*. In spite of these variations, it was difficult to separate the two forms.

The white body-colour, mantle with yellow to orange border, and fine orange to vermilion-red reticulations all over the central dorsal surface easily determine this attractive species. In the white space between the border and the reticulations are a number of orange–red spots. About 4–6 irregular spots are on each side of the specimen collected on the 12th June, and in the earlier specimen there are a few more. Also, the gills of the former are whitish slightly tinged with colour and the rhinophores are light coloured at their base, with red-brown tips, whilst those of the latter are quite reddish. Both specimens have a yellow border to the mantle undersurface, and a yellow-orange border round the foot and head, with yellow tips to the orals. The gills number eight to ten. At times, the white spaces enclosed by the fine reticulations on the dorsal surface have an almost pustulose appearance. The animal adopts a rounded-ovate shape at rest and elongates itself when crawling.

Measurements.—20 mm. long, 10 mm. broad (4th June); 25 mm. long, 6 mm. broad, crawling (12th June).

This is the first record of this species from Australia and it had not been noticed in the locality previously. Risbec (1928, pp. 135–7) records as *Chromodoris alderi* Coll., a similar species from New Caledonia. He makes no reference to *reticulata* Pease, and may have been unaware of that species, otherwise he must have noticed their similarities. Eliot (1904, p. 386) records specimens from the east and west coast of Zanzibar, and notes variation in colouring of the species. He appears to be the first author to note that *alderi* seems identical with *reticulata*. Baba (1933, p. 169) places *alderi* as a synonym of *reticulata* and reports that it is common in the spring at Tomioka, Japan.

Mrs. L. Woolacott collected a larger specimen of this species (1½ inches long, crawling) in the Angourie Pool, in November, 1945. This had the pale colouring noticeable in some of the specimens collected previously.

Glossodoris lineolata (Van Hassalt), 1824.

(Plate xli, figs. 16–17.)

Doris lineolata Van Hass., 1824, p. 258.

The specimen agrees with the type in general appearance and also with the various species regarded as synonyms of *lineolata*. The animal is typically Glossodorid in shape, attenuated when crawling, the tail protruding to some extent beyond the mantle.

The dorsal surface colouring is creamy-white with fine longitudinal chocolate-brown lines, ramifying in places. The upper surface of the tail is faintly marked in the same manner. The mantle is outlined with a bright orange border. The gills, which number seven, but branch somewhat towards the tips, are orange-coloured, dark-tipped. The rhinophores are brilliant orange-red, dark-tipped also. Both the gills and rhinophores stand out conspicuously against the dark background of the mantle. There are longitudinal lines, as on the dorsal surface, along the sides of the foot, which is outlined with orange. The orals are orange-coloured at their extremities. The colouring of the undersurface is pale bluish-white. On the dorsal surface the lines may appear as white

lines against a brown background or *vice versa*. The species is slight and rather delicate, but most attractive in appearance.

Measurements.—Approximately 1½ inches long, ½ inch broad (crawling).

Locality.—Angourie Pool. This specimen was collected by Miss G. Thornley, who kindly prepared a colour sketch of it in the field.

Glossodoris striatella (Bergh) and *Glossodoris funerea* (Coll.) are synonyms. I consider the New Caledonian species *Glossodoris clavata* (Risbec) [1928, p. 151] as a synonym also. Although there is apparently slight variation in the colouring of the Japanese species, *Glossodoris katoi* Baba (1938, pp. 131–132) it appears very close to *lineolata*.

Glossodoris sp.

A very small, rose-pink *Glossodoris*, with darker rose spots over the dorsal surface, seems unidentifiable at present. The gills and rhinophores are light pinky-yellow, and there is a deep orange-vermilion border to the mantle, which at times appears like a slight orange line inside a vermilion one. There is a suggestion of a white space immediately inside the coloured border. The gills number ten. The foot and tail are rose-pink, and the sides and undersurface of the foot dotted with dark red. In one specimen the spots were more orange than red.

Measurements.—Three specimens, 3 mm., 12 mm., and 15 mm. long, respectively.

Locality.—Angourie Pool, at low tide, on weeds, 5th June.

As this little species gave the impression that it was immature, it is possible its colouring might vary with full growth and, although no species could be found quite like it in the literature, it was considered wiser to refrain from regarding it as a new species at this stage. Further material will possibly clear its identification.

Subfamily THORUNNINAE.

Genus Rostanga Bergh, 1879.

Rostanga Bergh, 1879, p. 353.

Animal small, somewhat like *Glossodoris* in shape. Surface covered with papillose-like granulations. Labial armature and radula present. Colouring either drab or vivid, with dark mottling in the form of irregular spots, on the dorsal surface.

Rostanga arbutus (Angas), 1864.

Doris arbutus Angas, 1864, p. 47. Coogee, near Port Jackson, N.S.W.

This small, orange-scarlet and black-speckled species was noticed wherever collecting was being undertaken. Half a dozen or more could have been collected at any of the places, but a record of its presence was noted only. The species is one of the commonest nudibranchs along the New South Wales coast, where it is found at low tide, mostly amongst weeds. It stands out vividly against the green background of the weed, and is popularly known as the Strawberry Dorid.

It appears that *Doris muscula* Abraham (1877, p. 256) and *Doris rubicunda* Cheeseman (1881, p. 222), from New Zealand, may be more allied to *arbutus* than is believed. Should they prove synonymous, Angas' name would have priority. The papillae-like granulations packing the upper surface, the simply pinnate gills and other related characters help to support this synonymy. Abraham's colour description is from spirit material. In preservative *arbutus* becomes a drab yellow-grey.

Baba (1935, p. 343–5) records as *Rostanga muscula* Abraham a species from Japan. He groups the three species *muscula*, *rubicunda* and *Rostanga pulchra* McFarland under *muscula*, omitting any reference to *arbutus*, which he possibly overlooked. I am inclined to think that eventually these related species will all be referable to *arbutus*.

Subfamily MIAMIRINAE.

Genus Casella H. & A. Adams, 1858.

Casella, H. & A. Adams, 1858, p. 57.

Animal compressed, elongated, with small mantle-margin forming undulated lobes along the sides of the back. Foot narrow, radula present, gills simply pinnate. Distribution, Indo-Pacific.

Casella atromarginata (Cuvier), 1804.

(Plate xli, fig. 21.)

Doris atromarginata, Cuv., 1804, p. 473. Sydney Harbour, N.S.W.

Although this species appears at intervals along other parts of the New South Wales coastline and at times quite commonly round Sydney, yet this was the first occasion on which Mr. Cameron had seen it in the vicinity of the Clarence River Heads. The body varied from light to dark cream and the border-line from reddish-brown to black while the specimen was being examined. The fourteen simply pinnate gills were creamy-brown, heavily tipped with purple. The rhinophores were very dark.

The species, which has a wide Indo-Pacific range, undergoes considerable colour variation.

Measurements.—Length, two inches.

Locality.—Collected in a shallow pool amongst weeds, at low tide, Woody Head, 9th June.

Subfamily DORIDINAE.

Genus Doris (Staurodoris) Linné, 1758.

Eliot (1906, p. 336) suggested it would be better to use the Linnean name *Doris*, rather than *Staurodoris* (established by Bergh, 1877, pp. 576—585), which could be maintained as a subgenus of *Doris*.

Later, Iredale and O'Donoghue (1923, pp. 197, 229) substituted *Doridigitata* Orbigny, 1839, for *Staurodoris* Bergh.

Thiele (1931, p. 434) adopts the generic name *Doris* Linné, 1758, for both *Staurodoris* Bergh and *Doridigitata* Ired. & O'Don., the type species being *D. verrucosa* Cuvier (*non* Linné). This classification is adopted here.

Doris (Staurodoris) pustulata Abraham, 1877.

(Plate xlii, figs. 1–2.)

Doris pustulata Abraham, 1877, pp. 256–7. Australian seas.

Several specimens of a *Doris* (*Staurodoris*) from Woody Head are referred to *Doris* (*Staurodoris*) *pustulata* Abraham, though they display some colour variation. The description and illustration of Abraham's species closely coincide with these specimens, and the establishment of a new species would be insecure, as Abraham was describing a preserved specimen, from which most of the colouring had departed.

For comparison with Abraham's species a description is given of the Woody Head specimens.

Body shape as in type. Dorsal surface covered with prominent rounded pustules, large in the centre, becoming smaller and more numerous towards the margins. Rhinophores fairly short, rounded, retractile into rounded openings, guarded by two large, lateral, almost cup-shaped tubercles, with smalller posterior and anterior ones, and a few even smaller ones, between them. These tubercles are capable of fitting completely over the rhinophore opening. The tubercular processes give a raised appearance to the opening. Gills eight, rather small in proportion to the size of the animal, bipinnate, arranged in approximately two groups, four on each side of the cavity, the last two being bifid. The long, tubular anus, with fluted edge to its opening, rises

between the posterior pair of gills. The gill cavity is guarded by a row of very large pustules with smaller ones between them.

Foot small, narrow, pointed posteriorly, about one-third the total width of the mantle. The anterior end is transversely slit, the anterior lamina notched. Orals in live specimens broad at base, fairly long and tapering (in preservative, as described by Abraham). Radula consists of a number of rows of crowded, simple, fairly long, smooth, hooked teeth on each side of the rachis. No medium tooth. Radula is broad. There is no labial armature, and the penis is unarmed. The whole surface, including the pustules, is spiculose and has a granulated appearance. The spicules stand out over the pustules like smaller pustules.

Colour.—The specimens showed considerable variation of colouring, ranging from dingy yellow-grey to rich orange-red, intermingled with yellow, and brown spotted. Some of them formed a perfect camouflage amongst the yellow-red spongy growth on which they were found. The ground colour varied from white to brilliant yellow, the dorsal centre being much darker, either brownish-green or brilliant orange-red. The dark area usually extends from between the rhinophores to the gills. Splashes of dark colour occur along the mantle; one large specimen had a row of dark orange blotches along the mantle edge and two rows of dark brown blotches between them and the rich orange-red centre. Gills vary from creamy-grey to orange, speckled inside with red and black. In some specimens the centre of the gills, in particular the three lower ones, is brilliant orange-red. Rhinophores may be reddish, yellow or grey tipped with orange. Pustules are yellow, with a white ring round the base of most of them. The undersurface is much paler, distinctly or indistinctly spotted with small reddish-brown speckling, principally on the mantle surface. Orals pale, dark speckled.

Measurements.—1½–2½ inches long, ¾–1¼ inches wide. The larger specimen is the one referred to with the large dark brown blotches of colouring. Its colouring is so vivid that a single specimen might appear as a distinct species, but on comparison with a number of the less vividly coloured specimens it is found to dovetail into the others.

Locality.—Woody Head, 9th June. On weed-covered rocks and amongst spongy growth, at low tide. The larger specimen had been collected on one occasion previously at Angourie Pool by Mr. Cameron.

Hedley and Basedow (1905, p. 151) apply the name *pustulata* Abraham to a species dredged in 20 fathoms, Backstairs Passage. I have collected specimens similar to those from Woody Head round Sydney and further south, and have always regarded them as *pustulata*. The northern specimens seem to establish Abraham's species.

The animal becomes considerably flattened and rounded when at rest. In general appearance the species resembles *Homoedoris japonica* Bergh, but the presence of plate-like scales on the vagina of the latter disassociates them.

Doris (Staurodoris) sp.?

A very small, dark moss-green nudibranch was at first thought to be a green form of *Doriopsis viridis* Pease, but on a close examination it appears to be an immature *Doris* (*Staurodoris*). The animal is firm and the dorsal surface is thickly studded with creamy-yellow pustules, which look like sand adhering to the dark green background. The five bipinnate gills, and the rhinophores, are creamy-yellow. The undersurface is light orange.

Measurements.—½ inch long, ¼ inch broad. A single specimen.

Locality.—Woody Head, 10th June, on weed in a small pool.

The species is unlike any Dorid hitherto recorded, but as it appears immature, its specific identification is left until more specimens are available.

Genus Doriopsis Pease, 1860.

Doriopsis Pease, 1860, p. 32.

As pointed out by myself previously (1932, p. 96), the genus *Doriopsis* Pease, which has been regarded as a synonym of *Dendrodoris* Ehrenberg, 1831 (= *Doridopsis* Ald. & Hand.) refers to an entirely different genus, the main characteristic of which is a semicircular-shaped opening to the gill chamber, through which protrude a number of linear, simply pinnate gills. Eliot (1907, p. 338) made a new subgenus (*Ctenodoris*) of the genus *Doris*, to include species having simply pinnate gills arranged in a line or crescent and the upper lip of the cavity shutting down over them. In this genus, which has the same characteristic as *Doriopsis*, he places his species *Staurodoris pecten* and *Doris flabellifera* Cheeseman.

Later Risbec (1928, p. 102) made a new genus *Guyonia*, into which he placed *Doriopsis viridis* Pease, 1861, and his own species *flava*. In 1930, Mde. Pruvot-Fol (1930, p. 291) noted the distinctiveness of *Doriopsis* Pease. Thiele (1931, p. 291) lists *Ctenodoris* Eliot as a genus, queries *Guyonia* Risbec (p. 439), and follows earlier authors in erroneously placing *Doriopsis* as a synonym of *Dendrodoris*. From observations it is apparent that *Doriopsis* Pease, *Ctenodoris* Eliot, and *Guyonia* Risbec are genera established on the same character and are synonymous. The characters of *Doriopsis* are sufficiently explicit to establish the genus and it should therefore stand.

In respect of the species affected by this synonymy, *pecten* Eliot (1906, p. 557) appears similar to *flava* Risbec, but as Collingwood (1881, p. 126) had already described a *Doris pecten* from Formosa, obviously a *Doriopsis* like Eliot's species, Eliot's specific name is preoccupied by that of Collingwood. If his species is the same as *flava*, then a new specific name is not required for Eliot's species from the Maldives. If they are distinct, which seems doubtful, a new specific name must be given to Eliot's species, as *Doris* (*Doriopsis*) *pecten* Collingwood is specifically quite distinct from *Doriopsis pecten* (Eliot).

Pruvot-Fol (1930, p. 295) places *Doriopsis* in the family Archidorididae.

Doriopsis flava (Risbec), 1928.

(Plate xlii, figs. 3–4.)

Guyonia flava Risbec, 1928, pp. 103–4. New Caledonia.

Several specimens of an orange-yellow Dorid seem indistinguishable from *Guyonia flava* Risbec, in particular the black-spotted form (Risbec, Pl. i, fig. 9). Its characters are as follows:

Animal oblong-oval, slightly depressed, firm, mantle thickly studded with small, rounded, rather flattened pustules. Rhinophores rather small, retractile, and coarsely lamellated. Gills sixteen to twenty-six, simply pinnate, middle ones the largest, decreasing in size towards the sides of the gill cavity. They are retractile into a fairly large semicircular opening, the upper lamina of which can fold down over the lower lamina, which flanges out slightly, permitting the edge of the former to rest upon it. When extended the gills protrude through the slit between the two laminae, but when withdrawn only the tips of the middle gills may be seen. Rhinophores set fairly well back. Spicules in the mantle are long and solid. Undersurface smooth. Buccal area prominent, especially in spirit specimens. There is no buccal armature. The radula has about 45–50 rows of numerous, similar-shaped, simple teeth. The penis is unarmed.

Colour.—General colour bright orange-yellow, rhinophores yellow to burnt orange. Gills yellow. Pustules have fine black speckling over them, the speckles also forming a ring at the base of each pustule. In this respect the species resembles Risbec's variety rather than the true *flava*, which is uniform yellow. However, young specimens of this display much variation of the dark speckling, and they may possibly be regarded merely as variation and not varieties. Undersurface yellow.

Measurements.—One specimen, 1½ inches long, ¾ inch broad. Other specimens measure 1¼ inches, ¾ inch, and ⅝ inch long respectively. Under rocks at low tide in the Angourie Pool, 5th and 12th–13th June. A specimen was also collected in November, 1945, by Mrs. L. Woolacott in the same locality.

This species is occasionally found round Sydney and at scattered localities along the coast of New South Wales. It approaches very closely *Doriopsis flabellifera* (Cheeseman) [1880, p. 222] from New Zealand, from which I can see little difference, both in colouring and general structure. However, as the tendency of the northern New South Wales molluscan fauna is to bear relationship to tropical species, in particular those from New Caledonia, rather than to those from the colder New Zealand waters, I am accepting the Australian species as *flava* Risbec, with the anticipation that eventually *flabellifera* and *flava* may prove synonymous. In this event the species would possess a wide range, the New Zealand form being one of the representatives of warmer seas met occasionally amongst New Zealand mollusca. Should they prove the same species, *flabellifera* would have priority.

In the New South Wales species the zig-zag folds described on the vagina of *flabellifera* are not apparent. The number of gills does not seem a permanent or reliable character, as they vary considerably.

Doriopsis flava, in particular the New Caledonian forms, may bear relationship to *Doriopsis granulosa* Pease (1860, pp. 32–3) from the Sandwich Islands, but Pease's description is too brief to substantiate this. It has already been pointed out that *Doriopsis pecten* (Eliot)—not *pecten* (Coll.)—seems identical with *flava*.

Doriopsis viridis Pease, 1861.

(Plate xlii, fig. 5.)

Doriopsis viridis Pease, 1861, p. 244.

Doris pecten Collingwood, 1881, p. 126. North Formosa. (Not *pecten* Eliot, 1906.)

An inky blue, very small, firm animal, with its mantle studded with small pustules of a darker colour. Rhinophores strong, lamellated, light at base, dark blue club. Gills 9–11, simply pinnate, set in a semicircular-shaped pocket, situated well down towards the posterior end of the mantle; smaller at the sides, darker blue than the body colour. Undersurface paler blue. When the posterior portion of the mantle shrinks, the gills stand out as though they are on the edge of the mantle. When the animal is alive it has the habit of pulling in the posterior portion of the body in this manner. Head and oral folds are a dingy yellow-blue. Foot bluish-yellow.

Measurements.—Two specimens, 10 mm. long, 5 mm. broad.

Locality.—Under stones, on weed, low tide, Angourie Pool, 5th–13th June. Two more specimens were collected a few weeks later by Mr. Cameron, and in November, 1945, Miss G. Thornley collected another blue specimen in the pool. Until the specimens were found in 1941 it had not been seen in the locality. This provides its first record for the species in Australia.

Risbec (1928, p. 105) considers *pecten* Collingwood a synonym of *Doriopsis* (*Guyonia*) *viridis* Pease. Under the latter name he places two varieties of these quaint little Dorids from New Caledonia—variety (a) is blue and typical of *pecten* Collingwood, whilst variety (b) is dark green, which may be the true *viridis* Pease. Our specimens so far conform to the blue form, but it is a matter of conjecture whether *pecten*, typifying the blue form, stands as a distinct species, or variety of species, or whether it becomes synonymous, as being a colour variation only, of *viridis*.

Subfamily ARCHIDORIDINAE.

Genus Archidoris Bergh, 1878.

Archidoris Bergh, 1878, p. 616. Type, *Doris tuberculata*, Ald. & Han.

Archidoris cameroni, n. sp.

(Plate xlii, figs. 6–7.)

A very pretty, bright orange-yellow animal, with white gills and rhinophores, contrasting with the yellow colouring of the mantle. The upper surface of the animal is strongly ornamented with large, elevated, rounded pustules, with smaller ones between them, the top of each pustule being tipped with small blackish-brown spots, which give a dark speckled look to the whole surface. The rhinophores are conspicuous, lamellated, and in preservative are slightly retracted into their cavities which are guarded by four small pustules. The six gills are very bushy, tripinnate, and preservation has retracted them almost to the edge of the gill cavity. The foot is broad, the orals conspicuous, cylindrical and folded. The radula consists of about thirty or more rows of crowded, simply hamate teeth on each side of the rachis, the inner ones being smaller and more crowded. No labial armature could be found.

Colour.—As stated above. There is a large brown-black patch of colour along the central dorsal surface and a small patch immediately in front of the gills, which are slightly tipped with black. The undersurface is orange-yellow, the foot being slightly speckled with dark colour on the sides but not on the sole.

Measurements.—One specimen, 1 inch long, ½ inch broad (crawling). When crawling, the tail extends beyond the posterior end of the mantle.

Locality.—Angourie Pool, 5th June. Under a weed-covered rock.

This species is referable to the genus *Archidoris*, but its specific status has been more difficult to determine. The only illustration it seems to approach is *Archidoris montereyensis* (Cooper) from Monterey, which appears too removed geographically to be applied to it with certainty. It does not agree with *Doris chrysoderma* or *Doris carneola* of Angas, although it is admitted the descriptions of both these species are brief, nor can it be identified with *Archidoris staminea* Basedow & Hedley, which was dredged in 20 fathoms, Backstairs Passage, South Australia. Bergh (1884, pp. 89–96) describes *Archidoris australis* from 95 fathoms, Kerguelen Is., but the Angourie species cannot be distinguished as that species.

As there appears to be no species with which this beautiful little nudibranch can be allied with certainty, I have given it the specific name *cameroni*, after the finder, Mr. A. A. Cameron.

Genus Trippa Bergh, 1877.

Trippa Bergh, 1877, p. 63; 1877, pp. 543–546; 1890, pp. 904–908; 1902, pp. 1098–9.

Trippa erinaceus (Angas), 1864.

(Plate xlii, figs. 8–10.)

Goniodoris erinaceus Angas, 1864, pp. 57–58. Port Jackson, N.S.W.

I can find no previous record of this species being placed in, apparently, its correct genus. It certainly is not a *Goniodoris*, and observations on the living animal, together with the description given by Angas, indicate its relationship to *Trippa*.

A single specimen collected at Angourie Pool, on the 4th June, is very like the illustration of the type. The whole upper surface consists of soft rounded pustules, heavily spiculose, giving the animal a hairy appearance. The rhinophores rise out of elevated spiculose sheaths, which resemble the pustules in shape. The six gills are very bushy, tripinnate, and partly retracted in preservation. The gill cavity is elevated almost to a point, its margins thin and slightly lobed. Foot is very broad, laminated at the anterior end.

Colour.—General body colour dark chocolate-brown with a reddish-purple tinge. A narrow, dull, orange-coloured streak runs down the dorsal centre of the mantle from between the rhinophores to the gills. Rhinophores are dark chocolate, white-

tipped. Gills very dark with a yellow line in the centre of each. Foot liver coloured with a reddish-tinge. Undersurface speckled between the mantle and foot, round the head and along the sole with tiny bluish-white speckles, which are also noticeable on the rhinophores.

Preservation has caused the specimen to become very soft, with smooth areas between the rounded pustules. The spicules on the pustules have shrunk to small protuberances. The colouring has changed to a dingy black-brown.

Measurements.—45 mm. long, 20 mm. broad (crawling).

Locality.—Angourie Pool.

Although collecting has been undertaken at different times in the type locality of this species, i.e., Garden Island, Port Jackson, the species seems very rare, and I have seen it only on one other occasion, alive. It has not been seen by Mr. Cameron previously. This is the most northerly record of the species to date.

I can see little difference, however, between this species and *Trippa ornata* Bergh (1877), recorded from Malay Archipelago, Philippines, Laccadives, and more recently from New Caledonia (Risbec). Beyond a more brownish tinge in *ornata*, the species seem close enough to suspect their synonymity, in which event *erinaceus* would take priority over Bergh's name. The fact that authors, in referring to *ornata*, omit reference to *erinaceus* leads one to suspect that they have overlooked the similarity of the two species. The apparent rarity of *erinaceus* along the New South Wales coast supports the view that this species, like several others of Angas, is a tropical form which has wandered into this State but is more environmentally suited to the Indo-Pacific. *T. ornata* seems, however, very close to *T. intecta* Kelaart (1859, p. 302). The three species may prove synonymous, in which event *intecta* appears to have slight priority.

Genus Peronodoris Bergh, 1904.

Peronodoris Bergh, 1904, pp. 44–45. Type, *P. cancellata* Bergh. Pacific.

Sclerodoris Eliot, 1904, p. 361.

Peronodoris Bergh apparently has priority over *Sclerodoris*, as recorded by Thiele (1931, p. 435). The animal has a hard texture, like *Platydoris*, but the dorsal surface is marked with various ridges and depressions, with pustule-like processes at their junctions or at intervals along the ridges. The surface has a granulose appearance, due to small bunches of tiny spicules over the entire area. There are no labial or genital armatures.

The genus *Sclerodoris* was established by Eliot for certain species, including *Doris apiculata* Ald. & Han., noting at the same time its resemblance to *Dictydoris* Bergh. Various workers find the diagnostic characters of *Dictydoris* and a near genus, *Halgerda* Bergh, so similar that they present no definite point by which they can be differentiated, although Thiele (1931, p. 436) lists them as separate genera. Eliot (1906, pp. 639, 645, 1000, 1002) later placed *apiculata* in *Halgerda* without reference to his own genus, a classification recorded later by O'Donoghue (1932, pp. 155–156).

In studying Alder and Hancock's original description and illustration of *apiculata* (1866, p. 122) and the excellent descriptions of several species of *Sclerodoris* by Eliot (1904, pp. 380–383), it appears that there are distinctive characters, in particular the fine but closely spiculose-granular surface of the species and the filaments of *apiculata*, which justified Eliot considering them different from *Dictydoris* generically and caused him to establish *Sclerodoris* which, unfortunately, is apparently preoccupied by *Peronodoris*. In neither *Halgerda* nor *Dictydoris*, in their true sense, is the granulated surface present, both of these genera being characterized by a smooth surface, although ridged; whereas in *Sclerodoris* the fine spiculose structure is apparent over the entire surface in all the species placed by Eliot in the genus and in the two species from New South Wales to be described below. If not a distinct genus, they at least form

a definite section in the *Halgerda-Dictydoris* group. More clarification of the group seems necessary.

In the meantime our two species are regarded as of the *Sclerodoris* type, as originally described by Eliot, but as pointed out above, this genus has become a synonym of *Peronodoris* Bergh.

Peronodoris apiculata (Alder and Hancock), 1866.

(Plate xli, figs. 22–23.)

Doris apiculata Ald. & Han., 1866, p. 122. East coast, India.

The likeness between the colour sketch of *apiculata* as supplied by Alder and Hancock (Pl. xxx, fig. 8) and the sketch of the live animal from Angourie is remarkable and leaves little doubt that they are the same species. Both they and *Peronodoris tuberculata* (Eliot) come close to *Doris incii* Gray, 1850, from Torres Strait, but their relationship cannot be established from the figure alone, as given by Gray (Vol. iii, Tab. 226). This latter species has not been recognized definitely from Australia since Gray recorded it.

A short description of our species is supplied for future reference.

The animal is elongate, leathery and hard to touch, rather elevated in the centre, flattened round the margin. The dorsal surface consists of a network of ridges, the more prominent ones intercrossed with shorter ones, giving a reticulate pattern to the surface. The ridges connect up prominent pustules, three conspicuous rows being on the central dorsal area. Smaller pustules are interspersed amongst them, but are always on ridges or, actually, at the junctions of ridges. About twelve pustules comprise each row on the central area. From the tops of some of these pustules the points of filaments, as indicated by Alder and Hancock, can be seen protruding in the preserved specimen, although these were not noticeable in the live specimens, as far as can be recollected. Over the whole surface is a dense granulation composed of minute bunches of tiny spicules.

The rhinophores are fairly large, but slender, and the six bushy, tripinnate gills are in a simple rounded gill cavity, the margin of which is slightly crenulated, due to the surface structure. The undersurface exhibits prominently the sponge-like reticulations described by Alder and Hancock. On breaking a piece of the mantle its undersurface is seen to be composed of masses of long, slender spicules. The medium-sized foot is laminated at the anterior end, with a grooved upper lamina. The orals are small and slender.

Colour.—General appearance is light creamy-brown. The actual body-colour, however, is lemon-yellow, with most of the smaller pustules tipped with rust colour and the larger ones white-tipped. The latter are most conspicuous against the darker background. The sunken spaces between the ridges on the dorsal surface are rich brown. The whole surface, in addition, is finely sprinkled with brown, and there are some small brown patches of colour round the mantle border. Rhinophores have cream stalks and rich brown clubs. Gills are creamy-yellow tipped with brown. The undersurface is lemon-yellow with some small brown spots round the mantle and foot edges and on the sole. The animal quickly loses its contrasting coloration in preservation, two small specimens becoming uniform lemon-yellow and the larger specimen a dingy yellow.

Measurements.—Two specimens, approximately the same size, 30 mm. long, 10 mm. broad (crawling). A larger specimen was found by Cameron in the Angourie Pool on 28th February, 1943. This measures, in spirit, 50 mm. long and 25 mm. broad.

Locality.—Angourie Pool, 6th June; Woody Head, 9th June. The specimen from the latter locality was slightly paler than the other.

The species seems very close to a species from Japan, described by Baba (1933, pp. 171–2) as *Halgerda japonica* Eliot.

Peronodoris tuberculata (Eliot), 1903.

(Plate xlii, figs. 11–14.)

Sclerodoris tuberculata Eliot, 1903, pp. 381–2. Zanzibar Harbour.

Somewhat similar in structure to *apiculata*, but tubercles are not so pronounced on the ridging, and the colouring is different entirely. In the spirit specimens the ridging appears the most conspicuous part of the dorsal surface of *tuberculata*, although pustules are present, but in *apiculata* both ridges and pustules are almost equally predominant.

The animal has the same hard, leathery texture as *apiculata*, the surface profusely granulated with minute bunches of tiny spicules. The dorsal surface is very elevated in the centre, with mantle margins somewhat flattened. Over the entire surface are small and large tubercles connected by ridges which, in the central area, are very strong, but become lower towards the margins. Between the ridges, in particular those on the central area, are deep depressions. One large depression is situated on the central dorsal line, a little more than midway between the rhinophores and gills, five along each side and one behind the gill. Smaller depressions occur between the ridges on other parts of the dorsal surface. The rhinophores are strong and there are eight bipinnate gills. The foot is fairly broad, but in preservation appears narrower in comparison with that on *apiculata*. Anterior end of foot laminated, grooved. Orals distinct, digitate. Radula has approximately 40 rows of about 50 simple teeth on each side of the rachis. There appears to be no labial or genital armature.

Colour.—The animal resembles a piece of greenish-brown sponge, similar to that among which it is found. A fine yellow dusting, like pollen, and dark brown patches of colour are scattered over the dorsal surface. Pustules and ridges are yellow, and the depressions between them are dark purplish-brown, with a conspicuous, almost black, spot in the centre of the floor of each large depression and in some of the smaller ones. The rhinophores and gills are orange-brown to tan-coloured and stand out conspicuously against the dark greenish-brown background. The undersurface is uniform deep orange, the mantle and sides of the foot being profusely speckled with brown. When alive and removed from its surroundings it is a very beautiful nudibranch.

Measurements.—2¼ inches long, 1¼ inches broad (crawling). A single specimen.

Locality.—Angourie Pool, amongst self-coloured sponge, 13th June, 1941.

There seems to be no distinctive feature to separate this species from *tuberculata* Eliot. His species is not figured, but the colouring, size, eight gills, and general description conform to our specimen. Eliot (1906, p. 667) regarded it as possible that his species might be the same animal as that described by Kelaart (1859, pp. 303–4) as *Doris castanea*, from Ceylon. He formed this opinion after examining Kelaart's type and a coloured illustration of the species, which Eliot reproduces in his paper (Pl. xlii, figs. 6–7), but admitted the identity could not be proved at that time from the scanty material supplied. There seems little in Kelaart's description to establish this relationship definitely. However, although the colour sketch of the upper surface of Kelaart's species resembles that of our specimen to a very slight degree, the undersurface (fig. 7) is exactly like the colour sketch made of the Angourie species. Whether *tuberculata* Eliot is eventually to become a synonym of *castanea* Kelaart remains to be seen, as fresh material from the two type localities needs to be examined before this can be determined. In the meantime our species compares favourably with *tuberculata* and is identified as such.

In spirit the animal has become a greenish-slate colour, with the tips of the pustules and ridges much lighter in tone. The rhinophore openings are slightly

elevated and crenulated round the edges, but not adorned with the nine valve-like structures, as in Eliot's species. The gills have retracted completely, the edges of the cavity being slightly raised and crenulated, forming a small opening.

The above two species, *apiculata* and *tuberculata*, are recorded here for the first time from Australia.

Subfamily DISCODORINAE.

Genus Kentrodoris Bergh, 1876.

Kentrodoris Bergh, 1876, p. 413. *K. rubescens*, Philippines.

Animal soft, dorsal surface minutely pilose, mantle broad. Tripinnate gills. Upper lamina of anterior end of foot deeply cleft. No labial armature. Penis armed with a style.

Thiele (1931, p. 436) uses *Centrodoris*. Pruvot-Fol (1934, p. 220) uses the family Discodoridídae and not family Doridídae, subfamily Discodorinae.

Kentrodoris funebris (Kelaart), 1859, p. 293.

(Plate xliii, figs. 10–12.)

Doris funebris Kelaart, 1859, p. 293. Ceylon.

Kentrodoris annuligera Bergh, 1876, pp. 423–427. Philippines.

Animal with wide, wavy mantle, very soft. Dorsal surface covered with deep, heavy, pilose growth, which breaks away easily. Foot wide anteriorly, deeply grooved, with upper lamina cleft, tapering to a much narrower tail. Orals slender, jaws absent, teeth simple, curved, fairly large. Gills large, tripinnate to quadripinnate, six in number. Structure otherwise as indicated by Kelaart and Bergh.

Colour.—Creamy-white ground-colour, ornamented with scattered, rounded patches of dark reddish-brown on the mantle and over the central dorsal surface, as figured by Bergh. The dark markings consist of heavy speckling on the pilose surface, ringed with dark colour. On the undersurface there is a regular row of separated spots along the sides and outer margin of the foot. Spots on the dorsal central area are larger than those elsewhere. In preservative the spots are black and the ground colour a dingy white.

Measurements.—Approximately 1½ inches long, ⅜ inch broad (crawling) but becomes almost circular in repose.

Locality.—Angourie Pool, June, 1941. In November, 1945, a very handsome specimen of this species was collected in the pool by Mrs. L. Woolacott, who prepared a colour sketch of it in the field. The ground-colour is white, and the spotting, rhinophores and gills a beautiful maroon-brown. According to various authors, the species varies from black to red-brown markings and a light fawn to white ground-colour. In preservative the spots on this specimen are now black.

In the study of this species a very interesting point has arisen. Bergh (p. 922) placed his species *annuligera* in with Cuvier's *Doris maculosa*, 1804, and Eliot (1906, pp. 649–650) follows this by listing it and *funebris* Kelaart (1859, p. 293) as synonyms of *maculosa* Cuv. He points out, and appears correct in this, that the species from Vanikoro, which Quoy and Gaimard identified as *maculosa* Cuv., does not look like it at all. Kelaart provides an interesting account of the egg-laying habits of his species. However, Pruvot-Fol (1934, pp. 220–223), in studying the Doridídae of Cuvier, has placed *maculosa* in the genus *Discodoris*, on the grounds that the granulations, typical jaws and teeth are those of that genus and not *Kentrodoris*. She reached this conclusion after a thorough anatomical study of Cuvier's type.

In identifying our species, however, which is undoubtedly the same as that named *annuligera* by Bergh and *funebris* by Kelaart, examination of the specimen has shown that it is definitely not a *Discodoris*, but is a *Kentrodoris*. The teeth are unlike those

of the former genus, but are similar to those of the latter; there are no jaws (a *Kentrodoris* characteristic); the anterior end of the foot is more deeply laminated than in *Discodoris*, the upper lamina is deeply cleft, and the structure of the dorsal surface is heavily pile-like, not granular, and remains that way to a considerable extent even in preservation. I had been doubtful of its synonymity with *maculosa*, in particular Quoy and Gaimard's specimen, although conscious that *funebris* and *annuligera* were undoubtedly the one species. Unfortunately our specimen is too soft and breakable to probe internally to any extent and, therefore, I was unable to locate a style to the penis, but the other characters show its affinity to *Kentrodoris* and conform to those given by Kelaart and Bergh. Alder and Hancock (1866, pp. 122–3) elaborate somewhat on Kelaart's description, pointing out that there is no jaw and the radula teeth are large and occasionally a bright grass green (teeth in our specimen are also large and are stained an orange tinge).

The species evidently cannot be allied to *maculosa*, but remains in *Kentrodoris*. The only species it is allied with is *annuligera*, over which it takes priority as the earlier name. As soon as possible it is hoped that a specimen of our species can be sent to Paris for comparison with the type of *Discodoris maculosa* (Cuvier).

This has proved one of the most interesting species in the collection. It is, in addition, one of the most handsome of the nudibranchs. Although it has been recorded as collected in Shark's Bay, Western Australia, by Péron, its appearance in the Angourie Pool provides the first record of the species from eastern Australia.

Genus Discodoris Bergh, 1877.

Discodoris Bergh, 1877, p. 61. Type, *D. boholiensis*. Bohol, Philippines.

Body subdepressed, rounded or oval, minutely granulated above, fairly soft. Margin of branchial aperture crenulated, bilabiated or stellate. Anterior margin of foot grooved, upper lamina divided. Labial armature present. Rachis bare, many simple teeth. Penis unarmed. Warm seas.

Discodoris nubilosa (Pease), 1871.

(Plate xlii, figs. 17–21.)

Doris nubilosa Pease, 1871, pp. 13–14. Society Islands. 6½ inches.

Animal very large and handsome. Elongate-oval, subdepressed, fairly firm. When alive, the entire dorsal surface is closely covered with simple and branched papillae of various lengths, but after preservation these become more granular in appearance. Rhinophores fairly prominent, with a slight backward bend, and set in slightly raised cavities, papillose to the margin. Gills bushy, rather small in comparison with the size of the animal, retractile, tripinnate, six in number. The margin of the gill cavity is divided into six shallow papillose crenulations, not strong lobes as in *Platydoris*. Anal tube with star-shaped orifice.

The foot is medium-sized, approximately one-third the width of the whole under-surface. The anterior end is grooved rather deeply, the groove extending well down the side of the foot, but gradually dwindling in depth. Upper lamina extends slightly beyond lower lamina and is rather deeply cleft. The labial armature consists of a pair of narrow, elongated, horny-yellow jaws, composed of minute rods. The radula is wide and has about 30 rows of numerous simple teeth on each side of the bare rachis.

Colour.—In life the ground-colour is creamy-fawn, with splashes of mottled grey-brown over the dorsal surface. Some markings form large dark spots, outlined with a rather broad, darker ring. Down the dorsal central area in particular there are a number of these large, black, irregular spots. This marking should not be confused with that of *Kentrodoris maculosa*, however, as the two species are quite unlike. The gills have blackish-brown stems, with yellow branches, tipped here and there with

brown. Rhinophores are dark brown. The undersurface of the mantle is bluish-white, heavily blotched with large, very conspicuous, chocolate-brown spots, situated close together towards the foot, but becoming smaller and more separated towards the mantle edge, with a few very small spots between them. Each large spot has a dark ring and a small dark spot in the centre. The papillae on the dorsal surface are yellow. The entire sole and sides of the foot are heavily mottled with dark brown. The markings on the undersurface form a strong distinguishing feature.

Measurements.—One specimen, 4½ inches long, 2½ inches broad (crawling). An immature specimen, one inch long, shows the heavy blotches on the sole of the foot, but the spots have not developed to the same degree on the undersurface of the mantle.

Locality.—Angourie Pool, under a large rock, 5th June. This species has not been seen in the district previously.

There are several named species, the characteristics of which are not clearly defined, but which come under consideration in the identification of this species. *Doris* (*Platydoris*) *infrapicta* Smith (1884, p. 91) from four fathoms, Queensland, superficially agrees with the Angourie species, and its locality might lend some support to this affinity. Several of Abraham's species, most notably *Doris inframaculata* (1877, p. 248) from Amboina, also approach our species, but again insufficient descriptions prevent their application with safety.

However, Pease (1871, pp. 13–14, Pl. 6) gives a full-size illustration of *Doris nubilosa* which, together with his clear description, leaves little doubt that the Angourie species is the same as that described by him from the Society Islands, although his species is slightly larger than ours. The two species have the same branched papillae, with simple ones between them, on the dorsal surface, the star-shaped anal orifice, and a very close similarity in their colour marking.

Some years ago I saw a specimen of this same species from the Great Barrier Reef and on that occasion, although only a brief consideration was given to its specific status, came to the conclusion that it most closely approached *nubilosa*. Although the species shows some variation from the characters as set out for the genus *Discodoris*, it has been so placed generically, since it has the labial armature, radula and unarmed penis of that genus. On the other hand, the branching papillose granulations seem more like the sculpture of *Thordisa* Bergh, 1877, whilst the rather deep slit in the upper lamina of the foot approaches *Kentrodoris* Bergh, 1876, but neither of these two genera possesses a labial armature.

The species known as *infrapicta*, which Smith put into *Platydoris*, may be the same, in which event *nubilosa* should have priority.

Discodoris palma Allan, 1933, pp. 448–9.

Discodoris palma Allan, 1933, pp. 448–9. Pussycat Bay, near La Perouse, Sydney, N.S.W.

Specimens of this species, collected at Shelly Beach, 6th June, and at Woody Head, 9th June, varied from dark rock colour to very pale grey or creamy-white, like sandstone. They were found at low tide amongst short weeds, on spongy growths, or flattened to the undersurface of rocks. In the latter position their colouring rendered them almost indistinguishable from the rocks. Those found on spongy growth were of a more pale yellow colour, resembling that growth.

The body is soft to feel, covered with small, elevated papillae, the upper surface mottled with darker, rounded patches of colour. In some specimens these formed a few rather irregular but inconspicuous rows down the central dorsal surface. The rhinophores are long and retractile, with pale bases, speckled white, and yellow, dark-speckled tips. Gills six, tripinnate, greyish, speckled with yellow. Foot broad, grooved anteriorly, orals linear. Sole and undersurface of mantle profusely speckled with a brown shade.

Measurements.—When crawling the average length is 2 inches, breadth 1 inch, but the animal becomes somewhat circular in shape when resting.

Although the animal is soft to feel, it is fairly firm, and when clinging to rocks is difficult to dislodge. Most of the specimens throw off portion of their mantle, as characteristic of the genus.

Subfamily DENDRODORIDINAE.

Genus Dendrodoris Ehrenberg, 1831.

Dendrodoris Ehrenberg, 1831, p. 94.

Soft animals, smooth or pustulose, with a suctorial buccal apparatus, and lacking jaws and radula. The mouth is a fine pore. Gills large, usually very bushy, and rarely number more than eight. Very abundant in the Indo-Pacific.

Dendrodoris denisoni (Angas), 1864.

(Plate xlii, fig. 16.)

Doris denisoni Angas, 1864, p. 45. Port Jackson.

Doridopsis gemmacea Ald. & Han., 1864, p. 126–7. India.

This species has been collected on several occasions previously by Mr. Cameron in the vicinity of the Clarence River Heads and has been found to undergo some variation in colouring. Our specimen was collected on the 12th June amongst short weed in the Angourie Pool. Preservation has robbed it of most of its colouring.

In the vicinity of the type locality, where it occurs at intervals, only small specimens—an inch or less in length—are usually found. As a general rule the Clarence River specimens are more than two inches long. The specimen from Angourie was one and a half inches long in a normal attitude. However, this may be purely coincidental, depending on the time of the year when the specimens are collected. The type locality is probably approaching the southernmost limits of the species' distribution, as it is obviously a tropical wanderer reaching colder waters.

The colour varies to some extent, so that the border of the mantle may be cream to bluish-grey, and the blue spots in the brown, lozenge-shaped areas on the dorsal surface may vary from brilliant peacock-blue to pale blue, and number from one to several in each area. The colouring of the gills and rhinophores may be light or dark yellow-brown. The typical soft pustules are present over the dorsal surface.

Bergh (1884, p. 694) was the first to recognize that *denisoni* Angas and *gemmacea* Ald. & Han. were synonymous, but placed them in the genus *Doriopsis* Pease, which has now been recognized as an entirely different genus from that first supposed. The acceptance of *Dendrodoris* to include many species hitherto placed in the genera *Doriopsis* and *Doridopsis* is now in general use.

Eliot (1907, pp. 91–92) doubtfully allies *Doridopsis gemmacea* Ald. & Han. with *denisoni* when recording the former species from Japan. Baba (1933, pp. 172–3) refers to a *Dendrodoris gemmacea* from Japan, about 70 mm. long. It is apparent that the two species are synonymous, with a wide Indo-Pacific range. *D. denisoni* has a few months' priority.

There are points of similarity, however, between the New Zealand species *Dendrodoris mammosa* (Abraham), 1877, and *denisoni* which suggest the possibility of a closer relationship than at present accepted. *Dendrodoris gunnamatta* Allan (1932, pp. 97–8), an inhabitant of the more muddy tidal flats round Sydney, is a species close to *denisoni*. The latter species is found along the rocky shore zone of our coast and does not frequent the muddy tidal flat.

Dendrodoris guttata (Odhner), 1917.

(Plate xlii, fig. 15.)

Doridopsis guttata Odhner, 1917, p. 62. North Western Australia.

A single specimen of a handsome little *Dendrodoris* can be identified as *Dendrodoris guttata* (Odhner), although its type locality is north Western Australia, and specimens have not been recorded previously from any intervening localities between there and the eastern coast of Australia. This is the first occasion on which *guttata* has been recorded from Australia since Odhner established his species. Baba (1933, p. 173) reports the species from Japan, where he says it is common in spring at Eisubana, Tomioka. It certainly has not proved to be common in Australia to date.

The Clarence River specimen appears to have only five gills, compared with six in Odhner's and Baba's species, but the number of gills in the Dorids does appear subject to variation. The animal is small, elongate, rounded at the ends. Surface smooth, yellow-red, with numerous, distinct black spots scattered over the upper surface, those at the sides of the mantle being slightly smaller than the centre spots. The rhinophores are rather stout, conspicuous, almost brick-red colour at their bases, with white tips. Between the white tip on each rhinophore and its stalk is a ring-like band of black. This colouring of the rhinophore forms a distinguishing characteristic. The five bushy tripinnate gills are yellow-red, slightly paler than the body colour, and are tipped with black. The undersurface is paler than the upper surface and is slightly more yellow round the head. The foot is broad.

Measurements.—Approximately 15 mm. long, 8 mm. broad (type specimen measured 8 mm. long, 3 mm. broad; Japanese specimen 20–30 mm. long).

Locality.—Shelly Beach, south of Angourie Point. Low tide, on a weed-covered rock, 6th June, 1941.

Dendrodoris nigra (Stimpson), 1855.

Doris nigra Stimpson, 1855, p. 380.

This very soft, smooth-surfaced nudibranch is widespread in its distribution throughout the Indo-Pacific, but is subject to the same amount of colour variation that is noticeable in some other Indo-Pacific species, such as *Casella atromarginata.* Several colour varieties of *nigra,* previously regarded as distinct species, are now accepted as synonyms.

The usual colour is a rich velvety-black, with or without white or yellow speckling over the surface, and a white, yellow, blue or other coloured band running round the edge of the mantle. Similarly, the rhinophores and gills may be tipped with white, yellow or other colours. A bluish bloom is often observed over the animal. The mantle is usually wavy and graceful, and the gills large and bushy. It is a most beautiful animal when seen in its natural habitat.

In 1932 I named a variety of this species, *Dendrodoris melaena* (1932, pp. 98–99). Since then many colour variations of the species have appeared along the New South Wales coast and I have come to the conclusion that these merge into one another and am of the opinion now that *melaena,* whilst it has definite colouring, is only one of the shades found in the species *nigra* and is not a separate species or variety. That these colour variations can cause complications is demonstrated with the material collected at Angourie alone. The species was very common in the pool, where it was found breeding on several occasions and, whilst the majority of the specimens ranged from a smoky black to deep black, with the usual amount of variation in spotting and coloured border, some lacked the latter and others had the mantle much reduced in width. A few specimens were almost liver coloured.

There was one colour variation, however, which resembled Bergh's colour sketch of *Dendrodoris nigra* var. *luteo-punctata* (1905, pp. 170–172), and as the distinguishing

features of this seem constant at present, the species has been named as such. The mantle was not so wide as in typical forms of *nigra*. The colouring was liver-brown and small yellow dots were scattered over the dorsal surface, many of them clustered into rosette-like bunches down each dorsal side. A blue border outlined the dorsal surface of the mantle. The gills and rhinophores were dark blackish-brown, tipped with yellow, and the foot a dingy pale orange with a few black spots. This particular specimen measured 1¼ inches long and ¾ inch broad, but the typical *nigra* may be two inches or more in length. As the colouring of Bergh's species, which is an East Indian form, and this variety from Angourie seem identical, the latter may be regarded as *nigra* var. *luteo-punctata* Bergh.

Family TETHYIDAE.

Genus Melibe Rang, 1829.

Melibe Rang, 1829, p. 129.

Animal with large head expanded into a veil, fringed round the margin. Rhinophores retractile into large sheaths. Back with leaf-like or other shaped papillae down the side, no distinct gills. Jaws, but no radula.

Melibe australis (Angas), 1864.

(Plate xliii, figs. 8–9.)

Melibaea australis Angas, 1864, pp. 62–63. Port Jackson, N.S.W.

A single specimen of this species was found in the Angourie Pool on the 4th June. Only once previously have I seen this species alive, and that was procured in the type locality. This is the first occasion on which Mr. Cameron had seen it, and apparently Angourie may be regarded as its most northerly record to date.

The species differs in no way from the Sydney one. The body is fleshy-white in life, elongate, with head expanded into a large cup-like veil, and tapering to a pointed tail posteriorly. Mouth is large, rounded. Rhinophores stand out from the veil and are retractile into long, trumpet-shaped sheaths. Margin of mantle veil is serrated. Body is marked down the dorsal centre with reddish-brown patches, principally between the protuberances and along their stalks.

There are no distinct gills, but there are a row of about four large, orange-yellow, puff-like protuberances along each side of the dorsal surface. These are the most conspicuous part of the animal. They are pitted with small holes and when on the rock the species looks very like a piece of yellow sponge. A few indistinct protuberances are situated between the principal ones, and it is obvious that the species has the ability to replace lost protuberances with new growths. While examining the live animal one of the protuberances fell off but showed considerable movement after it had become detached.

The small holes in the protuberances are arranged in about 3–4 rows. One hole in the centre is larger than the others. In preservative the protuberances appear pustulose and the sides of the body and the veil are definitely pustulose, although the pustules were not conspicuous when the animal was alive. The mouth is wide and, when opened out, is laminated longitudinally for some length. There appear to be no jaws and a radula is absent.

The animal measured 26 mm. in length.

In their enumeration of the known Australian species of nudibranchs, Basedow and Hedley (1905, p. 137) have placed *Melibe australis* Angas in the genus *Doto* Oken, 1812 (fam. Dotonidae). Thiele (1931, p. 449), on the other hand, records *Doto* as a synonym of *Idulia* Leach, 1852 (fam. Idulidae). Alder and Hancock (1846, pt. 2, fam. 3) point out that *Melibe* differs from *Doto* in having the large funnel-shaped veil fringed inside, and a proboscis-like mouth (which *australis* has). Thiele mentions a

jaw plate being present in *Melibe* but absent in *Tethys* Linné (1758), 1767, the other genus of the family, but our species seems more allied to *Melibe* than to *Tethys*. Its proboscis-like, laminated mouth and other characters definitely remove it from *Idulia* (= *Doto*), which has jaws and radula, and may require it to be removed later altogether from either *Melibe* or *Tethys*. The genus *Melibe* is the one into which it most conveniently falls at present, and the species is therefore being left as Angas placed it. In any event the species should not be placed in the family Dotonidae and is removed to its more correct family, Tethyidae.

No other species of the Cladohepatica nudibranchs exhibits the peculiar puff-like type of protuberances characteristic of *australis*.

Family AEOLIDIIDAE.

Subfamily AEOLIDIINAE.

Genus Baeolidia Bergh, 1888.

Baeolidia Bergh, 1888, pp. 777–8. *B. moebii*. Mauritius.

A genus characterized by the peculiar structure of the rhinophores. These are conspicuously ornamented with crowded knobs, arranged, more or less, in rings round the rhinophores. The cerata are flat and leaf-shaped. Only a few species known.

Baeolidia major Eliot, 1903.

(Plate xliii, figs. 1–7.)

Baeolidia major Eliot, 1903, pp. 252–3. Zanzibar.

This species was collected on a previous occasion in the Angourie Pool by Mr. Cameron and sent to the Museum. The notes and illustrations prepared by myself at that time are therefore included in this paper. The species was not seen during the June, 1941, collecting trip. The type locality of the species being Zanzibar, it is interesting to note that Baba (1933, p. 178) has found it in Japan. This first record of *major* from South-western Pacific waters not only widens its distribution, but adds a very interesting genus and species to the Australian list.

The animal has an elongated, narrow body with rows of leaf-like cerata down each side and extending inwards over the dorsal surface. These are easily dislodged and are replaced with new growths. The conspicuous rhinophores are covered throughout their length with pronounced knobs. The radula consists of about 32 pectinate teeth, the unusual shape of which is typical of the genus, and can be understood by reference to the illustration (fig. 5). The jaws are large, thin, and simple. The reproductive orifice is below the first row of cerata on the right side of the body, and the lateral vent below the second row, from the anterior end of the animal (fig. 3).

Colour.—General colour rather indefinite, light greyish-brown with some mottling. Cerata with bluish tinge, merge into pinkish-purple towards the points of attachment. Rhinophores showed signs of mottling and the foot was white. In its colouring the species seems to approach variety *ornata* Eliot (p. 254), but is probably only a slight colour variation of the typical *major*.

Measurements.—Three specimens, two of approximately 1½ inches in length and the third specimen slightly smaller.

Locality.—Angourie Pool, crawling on sand and stone in the bottom of the pool at low tide, 4th January, 1939.

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EXPLANATION OF PLATES.

Plate xli.

Fig. 1.—*Cyerce nigra* var. *ocellata* Bergh. Complete animal.

Fig. 2.—*Cyerce nigra* var. *ocellata* Bergh. Ventral surface of head region.

Fig. 3.—*Cyerce nigra* var. *ocellata* Bergh. Both sides of a single cera to show position of coloured spots.

Fig. 4.—*Glossodoris bennetti* (Angas).

Fig. 5.—*Glossodoris inornata* (Pease). Dorsal view.

Fig. 6.—*Glossodoris inornata* (Pease). Side view.

Fig. 7.—*Elysia marginata* (Pease). Side view.

Fig. 8.—*Glossodoris decora* (Pease). Dorsal view of complete animal.

Fig. 9.—*Glossodoris decora* (Pease). Ventral view of anterior end of animal.

Fig. 10.—*Glossodoris decora* (Pease). Outline of white markings on the dorsal surface, as seen in preserved specimen.

Fig. 11.—*Glossodoris daphne* (Angas). Dorsal view.

Fig. 12.—*Glossodoris daphne* (Angas). Ventral view of portion of animal showing head region and coloured border on undersurface of mantle.

Fig. 13.—*Glossodoris daphne* (Angas). A single gill.

Fig. 14.—*Glossodoris geometrica* (Risbec). Dorsal view.

Fig. 15.—*Glossodoris mariei* (Crosse). Dorsal view.

Fig. 16.—*Glossodoris lineolata* (Van Hasselt). Side view of animal crawling.

Fig. 17.—*Glossodoris lineolata* (Van Hasselt). Ventral view of portion of animal.

Fig. 18.—Rhinophore of *Glossodoris reticulata* (Pease).

Fig. 19.—*Glossodoris reticulata* (Pease). Dorsal view.

Fig. 20.—*Glossodoris reticulata* (Pease). Ventral view to show head and coloured borders to foot and mantle.

Fig. 21.—*Casella atromarginata* (Cuvier). Side view.

Fig. 22.—*Peronodoris apiculata* (Ald. & Han.). Side view.

Fig. 23.—*Peronodoris apiculata* (Ald. & Han.). Ventral surface to show position of coloured spots and sponge-like reticulation.

Plate xlii.

Fig. 1.—*Doris* (*Staurodoris*) *pustulata* Abraham. Dorsal view.

Fig. 2.—*Doris* (*Staurodoris*) *pustulata* Abraham. Ventral view of portion of animal.

Fig. 3.—*Doriopsis flava* (Risbec). Dorsal view.

Fig. 4.—*Doriopsis flava* (Risbec). Few pustules from the dorsal surface to show shape and position of colour markings.

Fig. 5.—*Doriopsis viridis* Pease. Dorsal view.

Fig. 6.—*Archidoris cameroni*, sp. nov. Side view.

Fig. 7.—*Archidoris cameroni*, sp. nov. Few enlarged pustules from dorsal surface to show shape and spotting.

Fig. 8.—*Trippa erinaceus* (Angas). Dorsal view.

Fig. 9.—*Trippa erinaceus* (Angas). Ventral surface of head region.

Fig. 10.—*Trippa erinaceus* (Angas). A single spiculose tubercle from the dorsal surface.

Fig. 11.—*Peronodoris tuberculata* (Eliot). Dorsal surface.

Fig. 12.—*Peronodoris tuberculata* (Eliot). Ventral surface of portion of animal.

Fig. 13.—*Peronodoris tuberculata* (Eliot). Bunches of spicules which closely cover the dorsal surface of the animal. In preservation these have become granular in appearance.

Fig. 14.—*Peronodoris tuberculata* (Eliot). Side view to show elevated dorsal area and arrangement of ridges.

Fig. 15.—*Dendrodoris guttata* (Odhner). Dorsal view.

Fig. 16.—*Dendrodoris denisoni* (Angas). Side view.

Fig. 17.—*Discodoris nubilosa* (Pease). Dorsal view.

Fig. 18.—*Discodoris nubilosa* (Pease). Portion of ventral surface to show position and nature of coloured spotting.

Fig. 19.—*Discodoris nubilosa* (Pease). A single coloured area to show broad banded outline and dark spot in centre.

Fig. 20.—*Discodoris nubilosa* (Pease). A few simple and compound filaments from the dorsal surface.

Fig. 21.—*Discodoris nubilosa* (Pease). Teeth from the radula.

Plate xliii.

Fig. 1.—*Baeolidia major* Eliot. Dorsal view of preserved animal. The cerata have fallen off, but their points of attachment may be seen along the sides of the body.

Fig. 2.—*Baeolidia major* Eliot. Typical cerata from the animal.

Fig. 3.—*Baeolidia major* Eliot. Portion of the dorsal right side to show position of reproductive organs (below the first row of cerata) and the lateral vent below the second row from the anterior end of the animal.

Fig. 4.—*Baeolidia major* Eliot. Ventral surface of anterior end of animal, showing head tentacles, knobbed rhinophores, buccal area, and grooved, winged anterior end of foot.

Fig. 5.—*Baeolidia major* Eliot. Serrated tooth from the radula.

Fig. 6.—*Baeolidia major* Eliot. Side view of radula, as in position.

Fig. 7.—*Baeolidia major* Eliot. The inner and outer view of the jaw.

Fig. 8.—*Melibe australis* Angas. Dorsal view of complete animal.

Fig. 9.—*Melibe australis* Angas. Portion of the buccal area showing elongated laminations on the inside of the proboscis-like structure extending from the mouth.

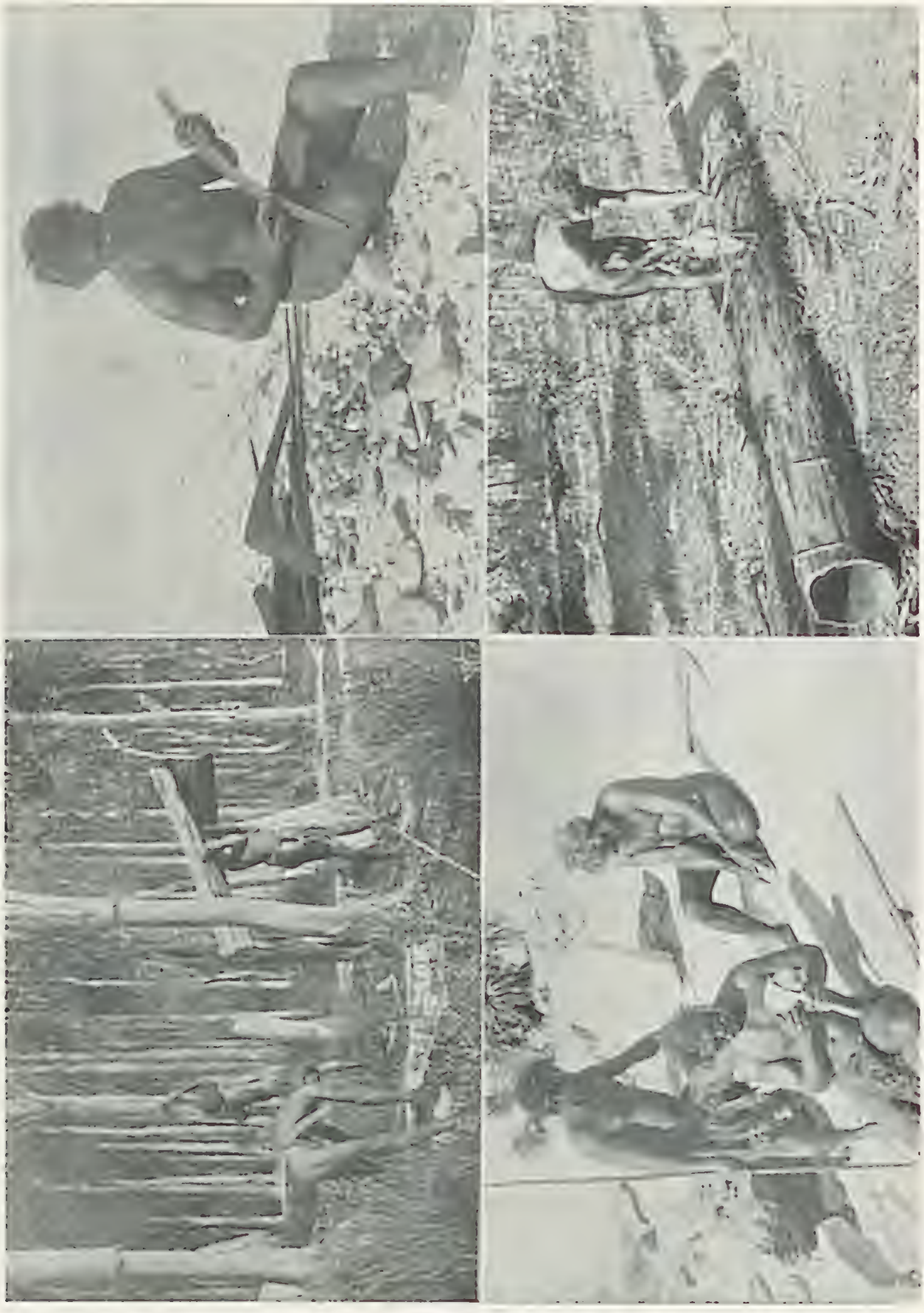
Fig. 10.—*Kentrodoris funebris* (Kelaart). Side view.

Fig. 11.—*Kentrodoris funebris* (Kelaart). Portion of ventral surface to show nature of spotting and pile-like granulation.

Fig. 12.—*Kentrodoris funebris* (Kelaart). Teeth from radula.

Note.—With the exception of *Baeolidia major* Eliot, the illustrations, other than anatomical, were prepared from the living animals and were originally in colour.

Joyce Allan, *del.*



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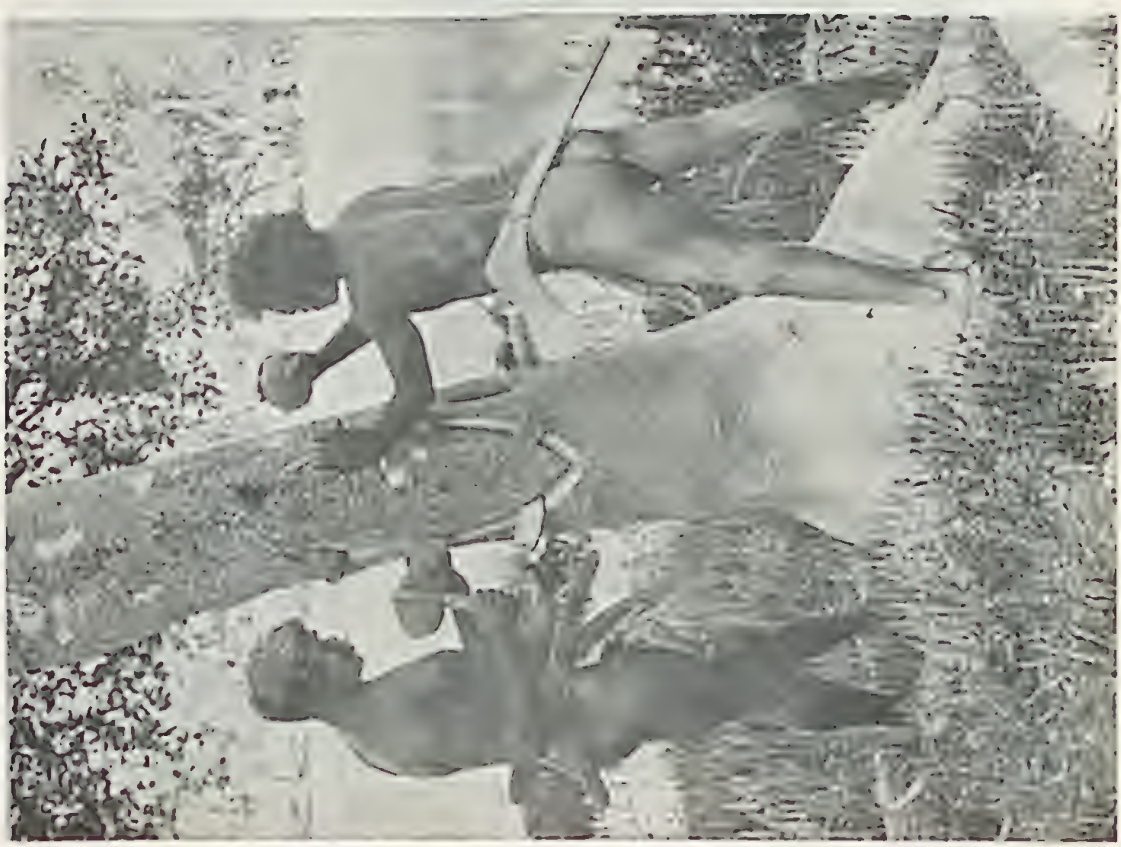

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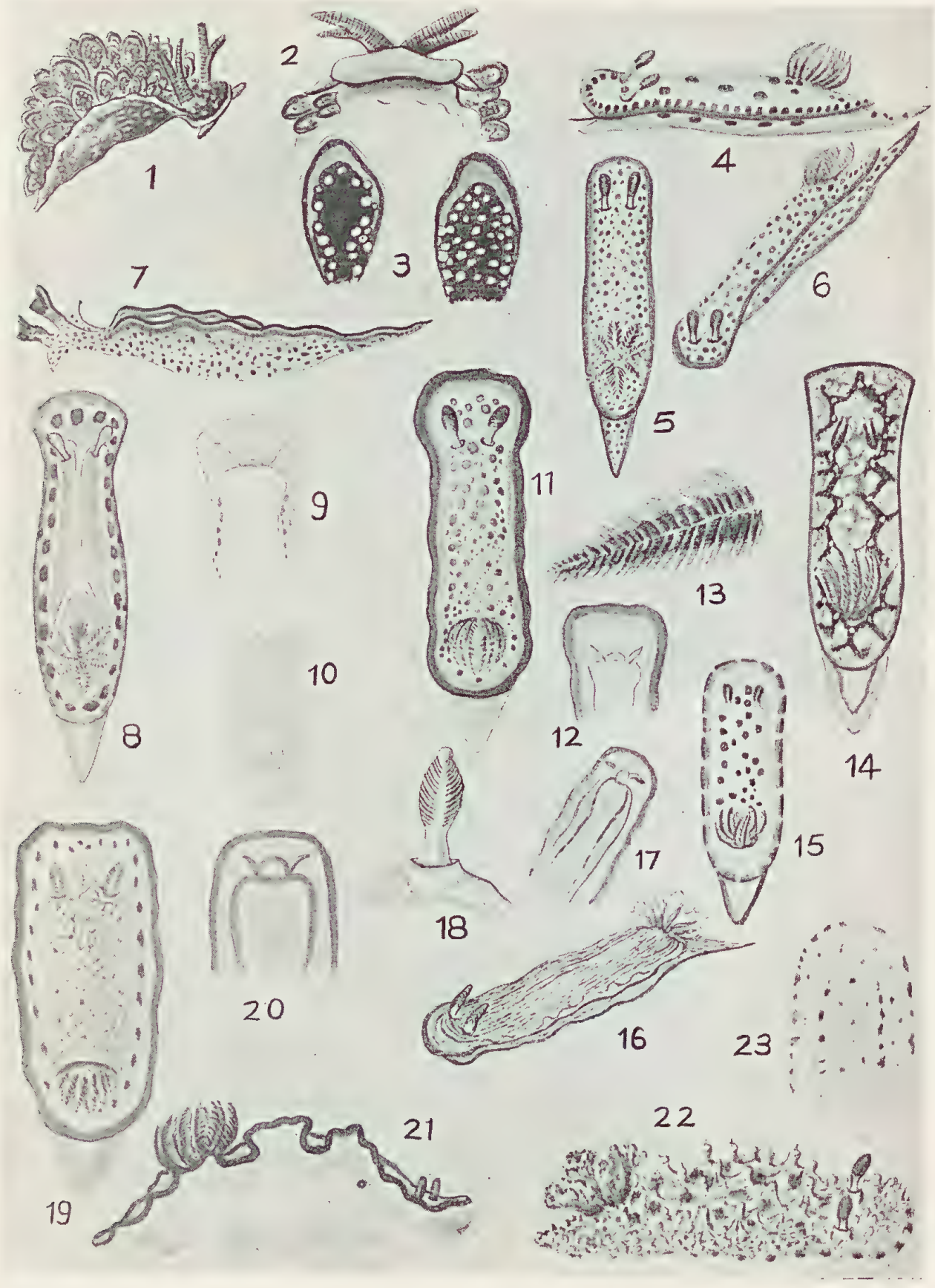
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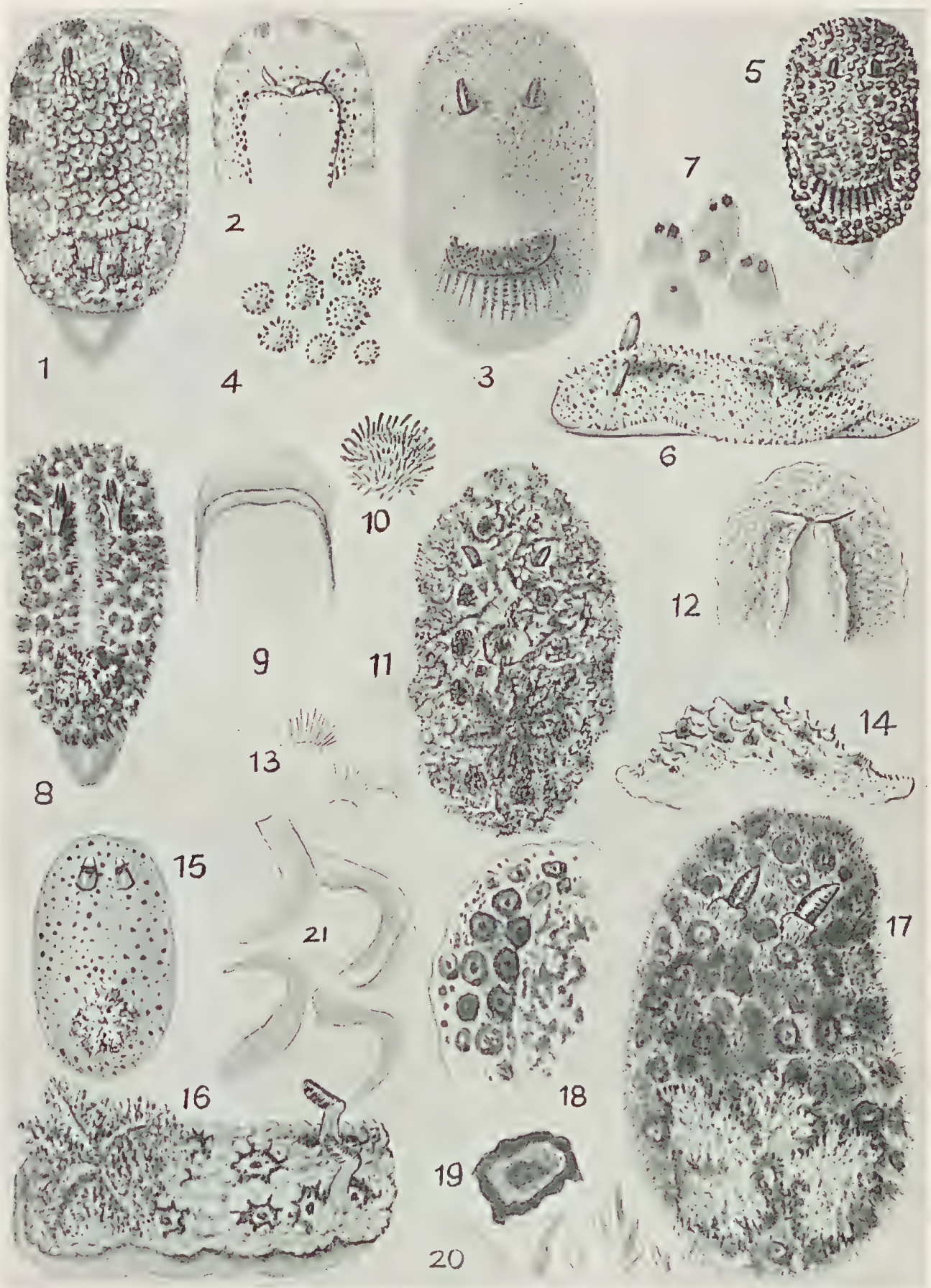
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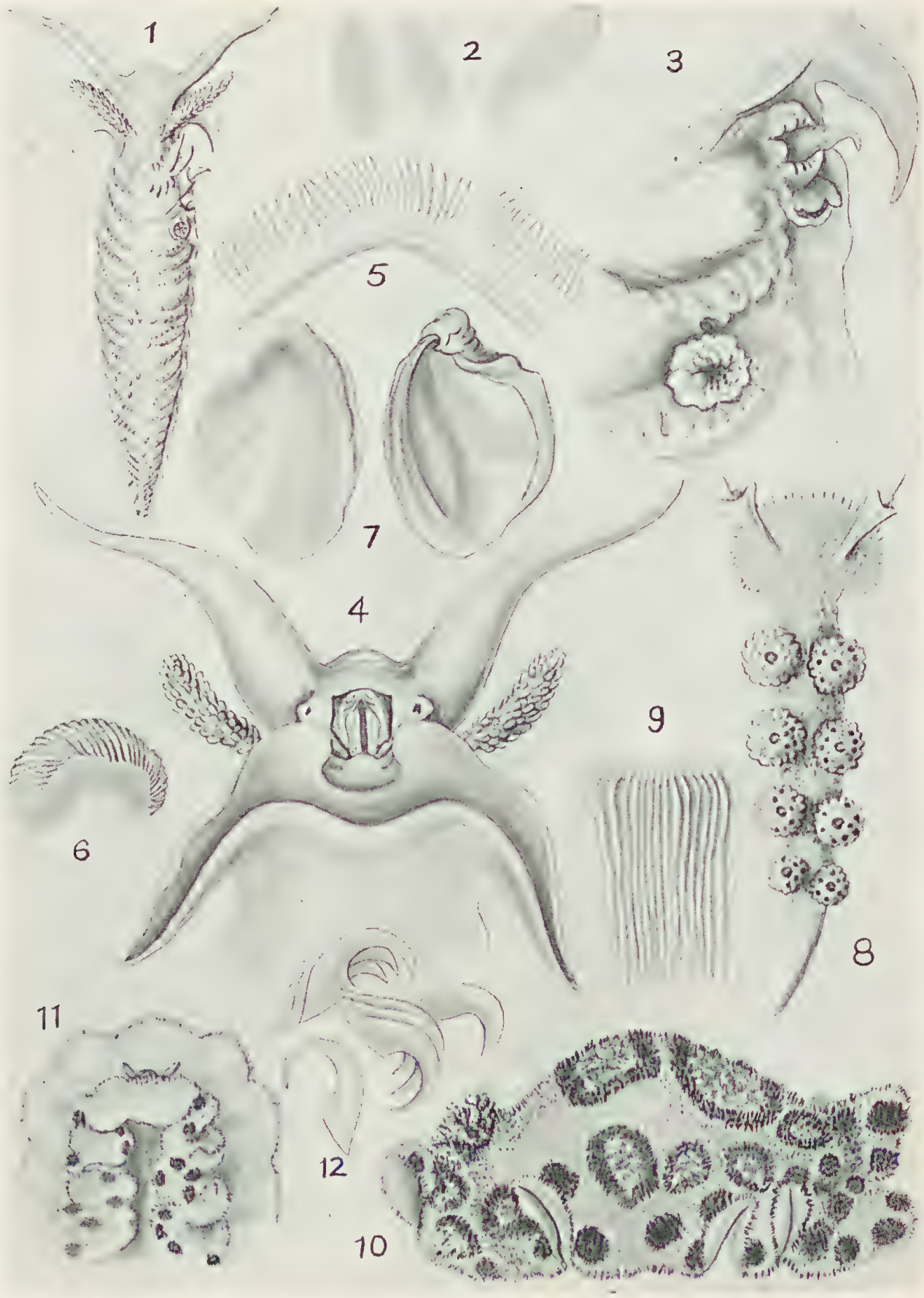
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